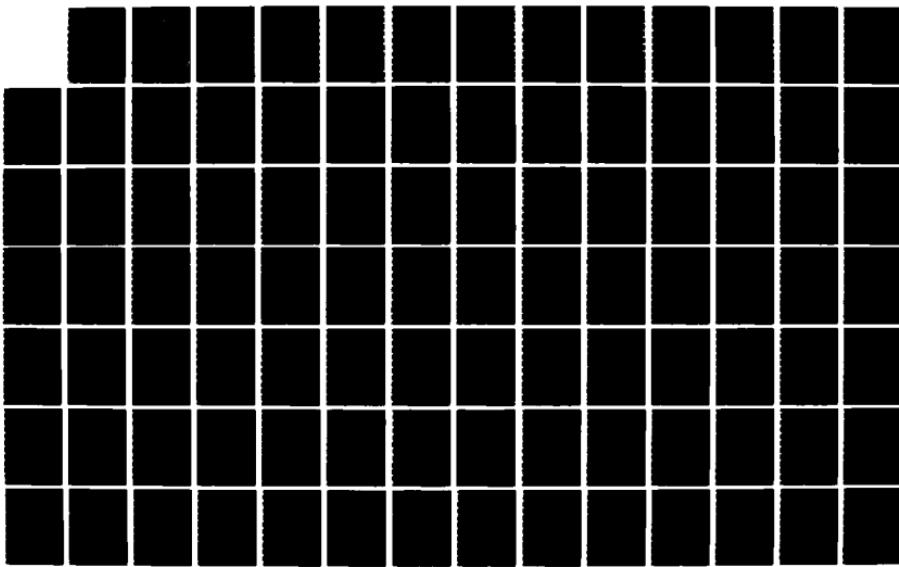
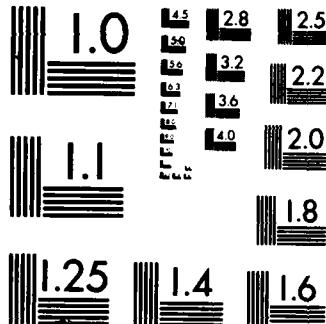


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AN EXAMINATION OF  
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AS POTENTIAL PARTNERS IN A JOINT  
SUPERSONIC MILITARY FIGHTER AIRCRAFT  
CODEVELOPMENT AND PRODUCTION PROGRAM

THESIS

Rockford J. Reiners  
Captain, USAF

AFIT/GLM/LSM/86S-64

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BRAZIL AND THE UNITED STATES  
AS POTENTIAL PARTNERS  
IN A JOINT SUPERSONIC MILITARY FIGHTER AIRCRAFT  
CODEVELOPMENT AND PRODUCTION PROGRAM

THESIS

Presented to the Faculty of the School of Systems and Logistics  
of the Air Force Institute of Technology  
Air University  
In Partial Fulfillment of the  
Requirements for the Degree of  
Master of Science in Logistics Management

Rockford J. Reiners, B.S.C.E., M.S.I.R.

Captain, USAF

September 1986

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Acknowledgments

I hope you will find this thesis informative and helpful. Any oversights or errors made must be directed to me for I was solely responsible for its content. I would like to thank the following people for their time and effort:

For providing information

Brazilian-American Chamber of Commerce  
Mr. Frank J. Devine, Executive Director

Embraer, Empresa Brasileira De Aeronautica

Mr. Salo Roth  
Vice President, Sales & Marketing, North America

Mr. W. Bartels  
Program Manager

For advice and help in writing the thesis

Lieutenant Colonel Robert D. Materna, USAF  
Thesis Advisor

First Lieutenant Ann W. Reiners, USAF  
Wife

Rockford J. Reiners

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Abstract

This thesis examines whether Brazil and the U.S. could be suitable partners in a joint supersonic military fighter aircraft program. The primary research method was a literature review accompanied by correspondence with the national aircraft corporation of Brazil, Embraer.

The research was divided into seven areas for study: aircraft design factors, aircraft production factors, aircraft operation requirements, business concerns, current activities, possible future actions and Brazilian-U.S. relations. In addition, three approaches for a Brazilian supersonic fighter development were investigated: licensing, joint venture and internal development.

The results of this research indicate that Brazil and the U.S. could be suitable partners for a joint supersonic fighter development program if the technology transfer and third country export requirements can be worked out to the satisfaction of both countries. Currently Brazil has an export driven aircraft industry while the U.S. insists on approval rights for all exports of Brazilian goods containing U.S. technology.

**AN EXAMINATION OF BRAZIL AND THE UNITED STATES  
AS POTENTIAL PARTNERS IN A JOINT SUPERSONIC MILITARY  
FIGHTER AIRCRAFT CODEVELOPMENT AND PRODUCTION PROGRAM**

**1. Introduction**

**1.1 General Issue**

The Brazilian aircraft industry is one of the greatest industrial success stories of modern times. From August 19, 1969, when Embraer was created by Brazilian Government Decree Law 770 (32:2), to the present, the Brazilian national aircraft company has grown from non-existence into one of the top ten general aircraft manufacturers in the world (50:23). This tremendous success has come through a judicious blend of hard work, planning and multinational joint ventures. Brazil has had multinational aircraft joint ventures with Italy, Egypt, the United Kingdom and the United States in commercial aircraft; and because of the Brazilian aircraft industry's growth, increasing sophistication and extensive use of multinational joint ventures the prospects for a joint U.S. and Brazilian military aircraft project should be examined.

The use of multinational joint ventures in industrial military production has shown increasing growth throughout

the world. There are many reasons for this growth and several of the most important ones are:

1. A desire by weapons procuring countries to increase their technological and industrial bases (55:6).
2. A desire to share and reduce risk while making use of several firms' complementary resources (65:57).
3. A desire to increase domestic employment within the weapons procuring countries (55:6).
4. An improvement in international relations between the participating countries (78:4).
5. Closer military operations with allies, requiring interoperable weapons systems for increased military effectiveness (78:4).
6. A desire to improve and maintain favorable trade balances between participating countries (55:5).

These reasons are examples of several different goals from multiple organizations involving the industrial production of military equipment. From the U.S. point of view, one of the most promising approaches to meeting these multiple needs is through multinational joint weapon system production between the U.S. and its' allies. The additional advantages from a multinational weapons system appear to be well worth the additional problems and complexities they entail. Therefore, this type of industrial military production may be expected to continue increasing in the future.

### 1.2 Investigative Issue

As a result of the factors cited above, a great deal of effort has been devoted toward finding suitable partners and producing multinational military weapon systems. The Brazilian aircraft industry has developed rapidly in the last ten years and may be considered for such a partnership with the United States. The specific issue addressed in this research is: **"Would Brazil and the United States be suitable partners for a joint supersonic fighter aircraft development and production project?"**

### 1.3 Importance of the Study

The topic of a multinational codevelopment and production project was selected because of its growing importance in the aerospace industry in particular, and the world in general. Brazil was selected for study as a potential partner for several reasons. First, Brazil is the single most powerful nation in the southern hemisphere. Second, Brazil has shown rapid recent industrial growth in virtually all aspects of its newly industrialized economy. Last, Brazil has recently been involved in numerous other codevelopment and production programs with other countries and appears to posses the potential to be an equal partner with the United States in such a project.

#### 1.4 Scope

The purpose of this thesis is to examine the major issues and considerations of whether Brazil and the U.S. would be suitable partners for multinational military aircraft development. The primary focus is on Brazil and the Brazilian aircraft industry. The only aspects of U.S. political and military interests which are addressed are those which directly effect the thesis topic. This thesis examines seven specific areas:

1. Aircraft Design Factors
2. Aircraft Production Factors
3. Aircraft Usage Requirements
4. Selected Business Concerns
5. Current Activities
6. Possible Future Actions
7. Brazil & U.S. Relations

Within these areas this thesis focuses on the primary Brazilian organization in such a partnership, the Brazilian national aircraft company known as Embraer.

The thesis is only a preliminary study to determine if the U.S. and Brazil could be suitable partners for a supersonic fighter project. Therefore, the thesis does not cover numerous specific and highly variable factors which should be negotiated and tracked continuously if such a

project were implemented. Examples of such factors include currency exchange rates, responsibility for import and export licenses, make or buy decisions of the industrial partners, design and production product interface control and relative wage rates for management personnel. However this thesis does conclude with a discussion of whether these detailed issues deserve further investigation in the further evolution of any potential U.S. and Brazilian joint supersonic fighter project.

1.4.1 Limitations. This research project had several limitations. First, the thesis is limited to the Brazilian aircraft industry and, therefore the results should not necessarily be extended to cover other industries in Brazil. Second, this study is focused on military aircraft so many relevant factors for this project may not apply to a commercial aircraft venture. This report reflects an accurate answer to the specific research question and not necessarily to the possibility of joint projects in other areas.

1.4.2 Assumptions. Throughout this study the following assumptions have been made. First, it is assumed that the reader has a basic familiarity with aircraft. Therefore, specific aspects of aircraft design and related terminology are not covered. Second, this paper assumes that the reader possesses a basic understanding of the

weapons acquisition process.<sup>1</sup> Third, the assumption is made that most readers are familiar with U.S. procedures involving the sale of military goods and services. Therefore, this facet shall not be covered in this thesis.<sup>2</sup>

### **1.5 Research Questions**

#### **1. Aircraft Design Factors**

- A) Does the Brazilian aircraft industry have the technical capability to be a full partner with the U.S. aircraft industry in design and development of aircraft?
- B) If yes, in what areas would Brazil have the most technical capability?
- C) If any training and education are necessary for the Brazilians or Americans to cooperate successfully in design and production, what is it?

#### **2. Aircraft Production Factors**

- A) Does the Brazilian aircraft industry have the industrial capacity to be a full production partner in such an endeavor?

-----  
1. For more information on the weapons acquisition process, see the USAF AFR 800-XX series of regulations.

2. For more information see THE MANAGEMENT OF SECURITY ASSISTANCE available from: Editorial Office (DISAM/DR), Defense Institute of Security Assistance Management, Wright-Patterson Air Force Base, Ohio 45433, USA.

B) If not, can the capacity be increased as necessary?

C) Do the Brazilians have any currently unused capacity?

### **3. Aircraft Usage Requirements**

A) Are Brazilian military fighter aircraft performance requirements sufficiently similar to U.S. needs to make such a project worthwhile?

B) Are Brazilian logistics support systems compatible with or similar to the United States' systems? If not, what can be done to remedy the situation?

### **4. Selected Business Concerns**

A) How do import and export policies and the laws of Brazil help or hinder such a project?

B) Who approves this type of project in Brazil? Would the best chance of success be in a commercial venture or a government to government venture?

C) What is the sales market the Brazilians are aiming for in this type of project?

D) What companies could be competitors and what companies could be partners in this type of project?

E) Are there any initial financing aspects which must be considered before investigating this type of project further?

## **5. Current Activities**

A) Are there currently any joint U.S.-Brazilian projects in planning, negotiation, design, or any other stage of execution?

B) If yes, what are they?

C) How were they initiated or executed?

## **6. Possible Future Actions**

A) Is Embraer interested in such a project?

B) What does Embraer envision as its future?

## **7. Brazil-U.S. Relations**

A) What has been the bilateral relationship in the past?

B) What is the current relationship between Brazil and the U.S.?

### **1.6 Definition of Terms**

**Break-even point:** "The amount of sales revenue or the number of units sold at which total costs equal total revenue: the point at which there is no profit or loss (89:704)."

**Contribution Margin:** "The difference between total revenues and total variable costs; it is the portion of sales revenue available to cover fixed costs"(89:704). The contribution margin for a fighter aircraft expressed as a percentage would be:

(Sales price - variable cost per aircraft)/sales price = percent contribution margin.

**Fixed Costs:** "Costs that do not vary in total with changes in activity level (89:675)." In a fighter project these costs come from the research and development and manufacturing facility set up. These are all the costs which cannot be changed after production of an aircraft has started.

**Internal Development:** This is where an organization accomplishes all aspects of a project by relying on its own resources. It may include education and training of employees and the purchase of equipment from sources outside the organization. The key point is that the total financial burden and control is born by the one main organization.

**Joint Venture:** This is a business venture where two or more organizations pool resources to produce a product or service for mutual benefit.

**Licensing:** "Issued either by companies or government agencies, licenses are exclusive rights to perform services in certain geographical areas (89:353)." This typically includes the transfer of all technology and know-how necessary to perform the service or manufacturing. Licensing is the process of using this type of business agreement.

**Variable Costs:** "Costs that change in total proportionately with changes in activity level (89:675)." These costs would include parts and labor that go into each fighter aircraft produced.

## **2. Research Methodology**

The purpose of this chapter is to outline the approach and method which was used in examining the question: "Would Brazil and the United States be suitable partners in a joint supersonic fighter aircraft development and production project?"

### **2.1 Approach**

The subject of a multinational aircraft development venture is a situation which is unique to each country involved and may continually change over time. Literature which was currently available on the Brazilian aircraft industry and arms regulations was examined and used first. Secondly, any necessary research information which was not covered by current publications was answered by Embraer. Embraer is the Brazilian national aircraft company and they agreed to help answer any particular questions which arose during this study. Thirdly, the Brazilian-American Chamber of Commerce provided information on Brazilian arms and industrial development and other issues affecting trade between these two countries. The literature available and information from Embraer and the Brazilian-American Chamber of Commerce provided both a broad background and very current information necessary to successfully accomplish this research.

The first step in carrying out this research was to do a complete literature search. Secondly, all relevant information from this search was summarized and included. Thirdly, any issues and questions which appeared or remained were directed to relevant organizations such as Embraer, the Brazilian Air Force or the Brazilian government. Lastly, this information was integrated with the previous written information to form the completed thesis.

### 2.2 Method Justification

The approach of a literature review combined with direct written interviews was selected as the best approach for this thesis topic. The literature review allows for a broad range of information to be gathered along with the historical and environmental context in which the subject organizations operate. Interviews and correspondence with the organizations involved enabled the author to update this information and fill in gaps of knowledge from the literature. This method allowed the thesis topic to be covered in both breadth and depth.

### 2.3 Literature Review

The literature which is available tends to fall into the same categories as the organizations involved. The

first category is information on Brazil and the Brazilian government. Of these sources both Perry (75) and Worcester (104) provide good information on the background and growth of Brazil up to the mid 1970's. Other relevant reports include: Young (107), O'Day (72), Marcella (60) and Leff (57). Of all of these sources, Young (107) provides the best total recent picture of Brazil.

The second area of published work includes U.S.-Brazilian military relations. Of the authors used, all four were military officers of the United States. The most comprehensive background comes from Branco (11) followed by Beckett (10). Two other authors were also helpful in providing information, Arrants (4) and Tarsoly (92), but their publications are limited in distribution to government personnel.

The third category of written material is that of detailed information on Embraer. Three authors provided much information on the subject: Baranson (7), Hudson (50) and Mura (66). However, the most relevant current information was provided by Embraer Aircraft Corporation.

The last area of published information is that of United States concerns on joint development projects. Rand Corporation with Michael Rich et al. (78 & 79) provided very helpful information in this area; however, the material was written on U.S./European and Japanese

collaborations. Both Baranson (7) and Katz (55) provided information which bears more directly on the thesis subject and technology transfer to the developing countries in general. Hudson (50) also covers this subject dealing only with civil aircraft technology transfer to Brazil in the initial development of Embraer. These various authors have written on concerns including financial, technical, management and political issues which may effect a joint development project. Unfortunately, there appears to be no published literature which directly addresses the thesis subject.

#### 2.4 Summary

Chapter two has provided an overview of how this research was performed. The research method used in this thesis was a literature review accompanied by personal correspondence. The combination of literature review and correspondence with the Embraer Aircraft Corporation provided a complete picture of the environment for a supersonic fighter aircraft project and of the corporate ability of Embraer Aircraft Corporation. In the written literature a large amount of information was found on the environmental and corporate aspects of the thesis topic, but a lack of information was found on the subject of U.S.-Brazil cooperation on a military fighter aircraft

project. This thesis is intended to provide this missing information and expand the literature available in the area of U.S. and Brazilian cooperation.

### 3. Background

The purpose of this chapter is to describe the general background of Brazil and Embraer Aircraft Corporation.

#### 3.1 Brazil's Background

3.1.1 Introduction. The purpose of this section is to acquaint the reader with the growth of a new world power in South America, Brazil. This is especially important because "the United States is likely to have more reasons in the 1980's to conflict with capitalist Brazil than with communist China" (58:199). This is not because of malice or evil intent toward the United States but rather because Brazil is a strong and rapidly growing capitalist country and its' naturally developing interests will increasingly compete with those of the United States. There may be direct conflicts of national interest in trade, energy policy, access to capital and technology, and possibly most important, nuclear and conventional military proliferation (75:21-22). Whether the U.S. and Brazil become enemies can be controlled; which is one reason Brazil was chosen for this study.

3.1.2 Present Power Status. There are many different arguments about what constitutes national power and its employment. Most models include the factors of geography, economics, military and politics. These models, or

definitions, also agree that without comparisons between countries, measurement is meaningless. Power is a relative thing. To be able to comprehend Brazil's emerging power it is first necessary to assess Brazil's current economic, industrial and military standing.

The Brazilians currently have almost everything necessary for the achievement of world power status, which is the long range goal of the nation's elite (75:21-22). Brazil must achieve three goals that can come only through self improvement; full and continuing economic development, adequate national security and, possibly most difficult of all, longterm political stability and recognition by other world powers.

The geographic and population base of Brazil is truly tremendous. In terms of land area, Brazil is the fifth largest nation in the world today (75:3). This land includes 17 percent of the world's potentially arable land (72:34). To put this into perspective, that is 3,290,000 square miles or bigger than the continental United States (107:9). The population is equally large since Brazil also has the sixth largest population of any country (60:160). In economic terms Brazil has the eighth largest economy in the world and is the second largest agricultural exporter now in existence (60:160). Brazil has the sixteenth largest military capacity on earth, in raw numerical terms, with

the additional possibility of nuclear weapons and delivery systems in the near future (60:160). Although Brazil relies basically on its' own capabilities, it is willing to ally itself as necessary to help Brazilian national interests (75:24).

As Brazil continues to grow as a major world power, it will need to achieve several things that all world powers have in common regardless of their political and economic systems, including solid economic development, military development and political stability and influence. Brazil does intend to continue its economic development of the geographic base, as do all nations, but what about its long-term military and political goals?

The Brazilian government's intentions are very clear. As General Meir Mattos wrote in his book Geopolitica As Projecoes do Poder in 1977:

"Our development will result however in the obligation of greater responsibility in the field of external security. We will be a world power by the year 2000 and this will depend on our vocation and inclination for power. We must nevertheless be prepared to exercise this power, protecting our interests whose dimensions, in geostrategic terms, have acquired world dimension" (107:112).

Brazil's military is continuing to develop toward this goal. The elected President of 1974, Figueiredo, instituted a political strategy "abertura" which is continuing. This policy is still being implemented by

Brazil's most recently elected President's, Tancredo Neves elected 15 Jan 85 {deceased}, and his successor Jose Sarney. The first aspect of this strategy is to promote political liberalization to bring more people and talent into the political process. The second aspect is a willingness to bargain with certain opposition figures. This will bring desirable political changes to improve the government's effectiveness. Third, the government is permitting and fostering the formation of new political parties in Brazil (72:9). This will hopefully provide Brazil with long-term political stability. With these changes Brazil will become a long-term world giant.

3.1.3 Resource Base. The resource base of Brazil is one of the greatest in the world, from the vast number of people and their talents to the natural resources. Brazil has all the necessary ingredients to rise into great power status and is doing so.

At present there are 143,000,000 people in Brazil (103). This is a larger base of people to build on than all the rest of South America combined (107:16). The population is especially important for the future when one considers that 90 percent of Brazil's population is under forty years old (4:6). The workers of Brazil are also relatively educated, with a worker literacy rate of

approximately 95 percent<sup>3</sup> (72:52). This human potential is very significant because if Brazil were able to educate, train, motivate and employ everyone it could rival any country in the world in production.

The natural resources of Brazil are equal to or greater than those of any other nation in the world. In considering Brazil's goal of long-term industrial and economic development the mineral reserves of Brazil may be as important as the population potential. Brazil's ore reserves are among the most valuable anywhere, including: 43 billion tons of iron, over 124 million tons of nickel, one billion tons of copper, 100 tons of gold, and bauxite(aluminum ore) and uranium (107:26,31). Brazil also has additional resources in smaller amounts: chromium, manganese, tin, quartz crystals, beryl, sheet mica, columbium, titanium, diamonds, thorium, coal and tungsten (105:481). In fact, Brazil has every mineral resource except one; sufficient oil, and it is taking steps to compensate.

The geographic positional advantages of Brazil and the United States are similar in many respects. Neither has successfully been invaded by a foreign power primarily because of geography. The country of Brazil is dominated

-----  
3. Reports of Brazilian literacy range from 40 percent to 95 percent. The difference depends on the definition of literacy and the population reported.

by three features; oceans in the east, mountains in the west and jungles. The Atlantic Ocean provides two important services to Brazil. The most important to development is trade routes. Brazil is able to ship goods directly to anywhere in the world because of its coastline. The ocean also provides invasion protection from other countries.

The geographic base of Brazil provides a sound foundation for its growth in world power. Numbers of necessary people already populate Brazil and they are being trained and educated for their role as a great power. Natural resources for continued industrial growth already exist in Brazil in both sufficient quantity and variety. Lastly, Brazil has a protected heartland that is advantageously located for trade. These assets contribute to Brazil's current economic growth.

3.1.4 Economic Growth. Brazil has been experiencing great economic growth for several decades. Brazil has adopted a long-term strategy to continue increasing its Gross Domestic Product, industrial diversity and trade, and to overcome limitations. The theme that runs through Brazil's economic strategy is to replace subsidies with incentives (72:35). Brazil's leaders hope this approach will continue to improve Brazil's status among economically developed nations. Continued expansion of the Brazilian

economy requires the penetration of new markets capable of absorbing its very substantial productive capacity. This need applies to Brazil's agriculture and raw materials, but especially to its increasing line of manufactured goods (75:27). Also, the government hopes this strategy will overcome Brazil's limitations so growth can continue at its present rate.

Many inefficient domestic producers are no longer protected by heavy subsidies and are facing difficult times. The exceptions are the emerging arms industry, several aluminum development programs, and a few other new areas of activity. Industry, in general, has slipped from its position of preference in Brazil's development plans. Brazil's industrial growth has become self sustaining without government backing because many government subsidies have been withdrawn. "Brazilian industry still is, for the most part, one of the most technologically sophisticated and highly diversified in the developing world. The fundamental attractiveness of Brazil's large domestic markets, developed infrastructure and bountiful natural resources has not changed" (72:31). Brazil intends to maintain its personnel base on which to build, overcome its oil limitation and provide political stability. This is possible because of the maturity of the industrial sector as a whole.

A primary national industrial goal is generation of foreign exchange earnings by increasing exports to help finance continued development. Another goal is to help provide a renewable energy source (alcohol) lessening dependence on oil (72:32-33). Industry has been greatly expanding as highlighted by significant advances in the production of steel, wheeled vehicles, electronic components, hydroelectric power and additional expansion into other technically sophisticated industries (75:19). These industries have had many accomplishments but one example which stands out is the Brazilian space agency. The space agency plans to launch two Brazilian-made satellites in 1989 and 1990 (69:60). Brazilian industry is becoming self-sustaining without government subsidies and continues to expand with a high degree of sophistication. Like other highly industrialized states, such as Japan and the United States, Brazil has a very large part of its economy made up of trade.

Trade provides Brazil with several important necessities for its growth. First, trade provides markets for Brazilian export of manufactured goods and raw materials. Next, trade generates foreign income to help purchase necessities for further growth and stimulate confidence for Brazil to secure long-term loans for development. The United States is Brazil's biggest trading

partner (106:33). Trade between Brazil and the United States has remained relatively constant, and unless it grows, U.S. influence with Brazil will decline. Currently Japan is gaining great influence. Japan is Brazil's most dynamic trading partner registering a 2,200 percent increase in trade from 1966-1974 (75:64). However as the size of Japan's gross trade has grown, the percentage increase has declined even though the growth remains substantial. One recent estimate of trade growth with Japan was 14.5 percent annual growth rate (85:3). The basis for trade between the two countries is that technology goes to Brazil and food and materials flow back to Japan. With this continued pattern of trade Brazil may become one of the most technically advanced countries.

Brazil has only two major limitations to continued growth in industrial power: financing and oil. Brazilians have been building a modern state where one did not previously exist, therefore, the Brazilian government had to build without a tax base. All governments can finance internally by only three methods; taxing, borrowing and inflation. Brazil is using all three to the maximum extent possible. Borrowing and the oil imports have caused the largest part of the foreign debt. Oil is very important to Brazil's trade account. During the 1970's oil payments grew from 7 percent of Brazil's foreign payments to 48

percent of foreign payments. A great part of Brazil's deficit is due to these payments. A comprehensive energy strategy is now a top priority in Brazil's growth plans (72:38). Brazil's foreign debt has grown from \$28 billion in December 1975 to \$54.4 billion in December 1980 (72:26), and then to \$100 billion in 1985 (28:1). Still when Brazil's debt is examined in relation to its GNP, the debt is manageable.

The Brazilian debt may be expected to decline. Brazilian borrowing has declined in recent years, and industry has developed to a point where it now provides a tax base. Brazil's main debt contributor, oil, has dropped in price and consumption. The main causes of Brazil's debt have been reduced, and with increased industrial exports, such as aircraft, this debt may start to decline in the near future. The prospects are so bright that even Barrons magazine writes about Brazil's current boom and rosy prospects for the future (49:13).

3.1.5 Military Power. The Brazilian military has always been South America's pacesetter. Brazil had the first military unit in history to leave Latin America on an expeditionary force when it sent troops to fight in WW II (101:391). Unlike many modern states Brazil has never had to call on any other country for military help. The Brazilians have always used their own troops, ammunition

and equipment in every action in which the military was involved. Brazilian attitudes are the reason for this as Brazil's elite ultimately expect Brazil to guarantee its own security (75:29). This has been Brazil's guiding tenet in all its military dealings. By following this approach, Brazil developed its own armament base, large conventional forces and is acquiring a potential nuclear weapons capability (70:22-27).

Brazil is one of the chief arms exporters to the Third World. Brazilian sales were extensive with over \$3.5 billion<sup>4</sup> in exports in 1985. This places Brazil fifth in the world in arms exports (15). Even though Brazil is a large arms exporter it has always armed itself first. The goal among aerospace manufacturers and the armed forces of Brazil is becoming self-sufficient, primarily because of difficulty in purchasing equipment and technology from other countries (69:60). "It is developing an impressive maritime surveillance capability and exporting a wide range of military equipment, such as aircraft and armored personnel carriers. It is furthermore striving to achieve self-sufficiency in military hardware" (60:161). Some

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4. Actual sales figures are classified by the Brazilian government so Brazil's ranking and dollar figures are debated by several sources. All the sources agree that Brazil's sales are substantial and that Brazil ranks between fourth and seventh in the world.

expect that Brazil will fulfill this goal by the year 2000.

Even though Brazil's military standing is its weakest aspect of national power the military forces are still massive. Brazil's armed forces now outnumber every other South American country's military. Brazilian military forces outnumber every other Latin American force by such an extent that Brazil's forces are as large as any other two Latin countries combined. Now Brazil is working on upgrading the quality of its military since the numbers are sufficient (75:31).

The ultimate goal is to have a force capable of strategic power projection similar to those of the United States and the Soviet Union. Currently the Brazilian Air Force is limited since it has no strategic air capability (101:X), and is working on basic power projection capacity. The first step has been with rockets and Brazil does have the potential capacity for launching and operating satellites (69:60). Even though the military is developing, emphasis continues to be on the traditional role of defense.

The Brazilian Air Force emphasizes light bombers and fighter aircraft suitable for local defense and close air support of ground forces. The other services are also still structured toward Brazilian self defense. The Brazilian Navy concentrates on mine laying, anti-submarine

operations, coastal patrol and other defensive activities (101:389). Brazilian Army forces continue with their basic division structure and stationing around Brazil's perimeter. The military power of Brazil is more than adequate to protect against any possible aggressor although Brazil cannot exercise a power projection capacity at this time.

The biggest long-term development for Brazil's military power projection is their nuclear ambitions. In June 1985, Brazil and West Germany signed a \$4 billion agreement which will give Brazil full nuclear capacity in 15 years (75:33). This, coupled with the Brazilian Air Force's capacity to launch rockets and Brazil's sizable uranium reserves, could make Brazil a strategic nuclear power in 20 years. Although this ambition has not yet been fulfilled it is a realistic desire for the Brazilians. A capacity of this magnitude would exceed all other nations except the U.S., U.S.S.R., U.K., and France, placing Brazil in the forefront of great power nations.

3.1.6 Political Power. Brazil's political system is very stable and its foreign diplomacy keeps improving. Brazil's intention to assume a more important international role means considerable attention must be given to the development of the nation's diplomatic capabilities. Some feel Brazil is fortunate since she already possesses "one

of the most professional foreign services of any developing nations" (75:24). A professional foreign service is indispensable in using political influence for national gains. The most obvious sign of increased political influence is Brazil's construction of a "security perimeter" around itself with an increased presence in the internal affairs of Bolivia, Paraguay and Uruguay (75:45). Brazil has accomplished this with a combination of stable domestic politics and directed foreign politics.

Brazil's domestic political stability is exceptional in the southern hemisphere. There has not been a coup, assassination or disorderly transition of political control in over twenty years. Brazil has very orderly elections every four years by a well educated electorate so this overall political stability may be expected to remain for the foreseeable future.

Brazilian influence in foreign affairs is expanding as well as diversifying. Throughout the country's history its foreign policy has been western and conservative. It remains fundamentally conservative but is becoming increasingly opportunistic. Brazil's political policy is solidly grounded in self interest. Brazil's positions on each international issue are carefully measured and weighed on each issue's own merits, and the Brazilians will choose their actions accordingly (75:23-24). Brazil is charting

its own course in diplomacy and their destination is not in doubt. The Brazilians oppose any international accord that tends to freeze the contemporary global configuration of power (101:281). They are structuring policy to change the global power standing and make Brazil a major power. Some perspectives on Brazilian-U.S. cooperation have been increased by an agreement between the two which recognizes Brazil's great-power ambitions (75:39).

3.1.7 Summary. Brazil is developing and may well become a world power at the beginning of the next century. The development is taking place in all aspects of national power from resource and industrial development to military and political expansion. The rich natural resources of Brazil are being developed and the people are being trained and educated to take advantage of them. Industrial expansion continues with minimal government assistance while Brazilian agriculture remains one of the strongest in the world. Problems in the economic areas of finance and energy are also slowly being overcome. The military forces of Brazil are capable of defending Brazil against any current threat and may be able to provide a very credible power projection capability in fifteen to twenty years. In the political arena Brazil has been able to remain stable while opening political participation to a larger share of the population. Brazil's foreign service is very skillful

in influencing other countries through diplomatic means and their skill is improving. With continued development across the spectrum of national power Brazil may rival the United States Soviet Union and China for influence in the Third World at the start of the next century. World power status is well within Brazil's reach.

### 3.2 Embraer's Background

Embraer [Empresa Brasileira De Aeronautica S.A.] is the national aircraft company of Brazil. As such, Embraer is also the basis of the Brazilian aircraft industry since all of the aircraft companies in Brazil have Embraer as their primary customer. Embraer was originally a government owned corporation but government stock ownership had declined to only 5.5 percent in 1984 (32:4). However, the government still controls the majority of voting shares. Since this company is the basis of the Brazilian aircraft industry, an understanding of Embraer's background is important before examining its total present capacity.

3.2.1 Introduction. As previously noted the Brazilian aircraft industry is a modern industrial success story. In this section the development of Embraer shall be traced briefly; first starting with the development of a national aircraft need, then to governmental actions creating and nurturing a domestic aircraft industry and lastly, through the growth of Embraer to its current market standing and

prospects for the future. From nonexistence to one of the top ten general aviation manufacturers, here is the need that started it all (50:23).

3.2.2 Need for Brazilian Aircraft Development. From the mid-sixties onward three limitations to Brazilian growth have pointed to the need for a domestic aircraft capacity. First, Brazil needed transportation across its vast distances without any significant rail, highway or river system and this led naturally to growth in use of general aviation aircraft. Secondly, a rise in world oil prices just after 1972 placed Brazil in a tenuous financial position with its dependence on oil greatly increasing its annual financial deficit position (7:30). Lastly, by 1974 the Brazilian government had a great awareness of the financial, economic, and technical benefits which Brazil would continue to forfeit if it continued to rely on foreign manufactures of aircraft (7:31). In 1973, 5 percent of Brazil's import expenditures went to the U.S. aerospace industry and that percentage was growing (7:31). With a view toward increasing aircraft use, increasing export items to other countries for financial reasons, and improving their own technological base, Brazil examined its options.

This examination indicated that Brazil could gain great economic benefits in five areas if it could move into

being an arms exporter (including aircraft) instead of an arms importer. First, arms sales contribute to a favorable balance of payments which become more important to Brazil each year. Second, arms exports help decrease unemployment and stimulate domestic industrial growth. Third, Brazil's unit costs for military equipment could be reduced by spreading fixed costs over a longer production run and this could help reduce governmental expenditures. Fourth, linkages between military and commercial sales in other countries could be exploited. Lastly, arms could be exchanged for resources, such as oil, in barter trade among nations (66:75). This last benefit would tremendously help Brazil in both finances and oil import needs.

3.2.3 Brazilian Governmental Actions. There were other reasons for encouraging development in domestic aircraft as well. Brazil had embarked on a military modernization program. This program included a provision for arms procured from foreign sources to be built in Brazil. A continued drive to increase Brazilian independence of foreign technology helped increase Brazilian options for determining its own future. Also, a commercial policy of import substitution was necessary to help slow and stop the growth of Brazil's foreign debt (50:25,26). The authorities were aware that traditional modes of foreign investments in manufacturing facilities

were not supportive of the attainment of economic and technological development goals (7:16). In some cases traditional investment methods actually hindered economic growth. Realizing the importance of productive sectors in developing technological growth, the Brazilian government started providing direct financial assistance to technology companies for selection, research and development of product and process technology ventures.(7:17).

Additionally, the government started a tax allocation system for Embraer. Under this system the government made offers of Embraer stock which could be purchased in lieu of 1 percent of payment in income tax, in effect, a tax subsidy (32:4). This emerging consciousness of financing and foreign enterprise's impact upon national technological development forced the Brazilian government to intervene in its technology transfer channels for the development of national interests (7:13). As with most large undertakings there was one event which triggered action from the Brazilian government.

The crisis which actually started the development of Brazil's arms industry, which includes Embraer, was the reduction in the U.S. Military Assistance Program (MAP) grant aid following the 1964 military revolution. Unable to afford European alternatives to U.S. arms, including jet aircraft, the Brazilian government began its drive for a

domestic industry (50:24). The Brazilian Aircraft Company {Empresa Brasileira de Aeronautica SA, Embraer} was established and organized in 1969 as a semi-public company (50:23). After establishing the company the next challenge was to help it grow.

Many countries have traditionally only licensed technology. Instead, the Brazilians have sought to acquire technology permanently. The acquisition of technology usually has happened indirectly through joint ventures whose terms have been clearly more favorable to the Brazilian firms than to foreigners (50:24). To help improve this transfer the Brazilian industrial structure was strengthened by forming the National Institute For Industrial Property (INPI) which helps improve the regulatory environment for Brazilians. It also helps national enterprises in negotiations with foreign firms for technology (7:19,20). The Brazilian government also went further than simple encouragement in its approach.

The government's approach to the foreign aircraft firms was to offer them joint-venture agreements, for example, the Xavante in 1970 and the F-5 in 1973. The government informed foreign firms that they must undertake a coproduction or licensing agreement on all military or general aviation contracts in Brazil (50:27). To provide domestic corporations a financial incentive to help

domestic aircraft production, Brazil levied a 50 percent tax on imported small aircraft and required importers to deposit the full price of each plane for one year without interest (50:28). Aside from actions toward foreign and domestic companies the government also took actions aimed toward foreign companies' branches in Brazil.

To forcefully stimulate foreign multinational companies to reinvest their profits in Brazil the government also levied a 12 percent limitation on repatriation of profits and regulations converting royalty payments (50:42). Even though Cessna had 60 percent of the Brazilian aircraft market prior to this time they were not willing to accede to these conditions. The Piper Aircraft Corporation; however, was prepared to accommodate the conditions imposed by the Brazilian government for technology transfer (7:31). Therefore Piper was to become a very important factor in the commercial development and growth of Embraer.

These governmental actions after the oil crisis have led to Embraer becoming one of the most successful import substitution projects in the past 12 years (50:23). How did the company actually grow in this very favorable environment?

3.2.4 Embraer's Growth. Most Brazilian firms involved in technology have shown a pattern of development that

combines several techniques. These techniques include formal licensing contracts, copying and adaptation without contracts, and imports of components (36:304). Indigenous development of technology typically takes place after these techniques have been used to some extent. Since Embraer acquired the basic skills for development it has become capable of planning its overall technology requirements for continued company growth. Embraer can also execute its plans with a capacity to support newly created technology. Embraer even possesses its own research and development organizations (7:29). How Embraer has achieved this is a tribute to its long-term view.

To start its development Embraer started implementing the basic government thrust in industrial development. This has meant following a two pronged approach to acquiring technology. First is the use of a series of research institutes for research and training of personnel. Secondly, acquiring technology from foreign firms has provided rapid access to technology (64:22). The keystone of which was "Embraer adopted a policy of joint-ventures as the principle means of transferring technology for the aircraft industry" (50:27). The first joint venture project of this type was coproduction of the Italian designed Xavante in 1970 (64:16). After this project Embraer, with a great deal of effort, was able to

negotiate a management service contract with U.S. firms for manufacturing technology and its domestic development (7:14). In this manner Embraer has acquired considerable technology through foreign companies (64:23). In addition to acquiring technology Embraer has also used joint ventures to acquire commercial success.

The first joint venture in civil aviation was a 10 year contract signed with Piper Aircraft Corporation in August 1974 and expanded in February 1975 (50:28). This helped bring considerable commercial success to Embraer. Even though Embraer may have designed its own general aviation aircraft the Piper deal allowed them to start immediate production with very low start up costs (64:23). This began Embraer's development from a small organization to a manufacturer of appreciable size.

Embraer's acquisition of aircraft technology followed the traditional steps in a production transfer: first, importing kits; second, importing kits of subassemblies and manufacturing aids {jigs}; third, importing incomplete kits and separate parts. In stage three Embraer's production program started including parts manufactured in Brazil (50:29). The nontraditional aspect of this development was the speed with which this process was carried out in gaining new technology for each Embraer project.

Embraer was involved in military aircraft production

from its founding. One of the first projects was production of the Xavante military trainer under license in 1970. Embraer later worked with Northrop in producing vertical tail assemblies and other components for the F-5 under an offset agreement in connection with the sale of F-5's to Brazil (64:16-17). The Xavante project brought basic production and design technology to Embraer. The F-5 agreement greatly expanded Embraer's capabilities in metal-to-metal bonding, composite materials, and numerically controlled machining (64:17). The F-5 project only lasted for 150 sets of structures but its impact on the company lasts until today (64:24). The acquisition of basic technical capacities was followed by acquisition of production capacities for commercial success.

After Embraer acquired the basic technical capacities from the Xavante and F-5 projects, Embraer followed the same steps in acquiring technology for the production of general aircraft. Piper aircraft transferred production capacity to Embraer within three years of starting their joint venture by following this process. This led to 60 to 70 percent of Piper aircraft products in Brazil being of Brazilian origin under the joint agreement (7:31,32). To gain this level of technical maturity required a large degree of firm and product specific knowledge. Development of this knowledge is based on experience and education and

is not easily replicable or transferable (36:299). Although Embraer followed a traditional route to gaining a new capacity, the speed with which they were able to do so is truly to the credit of Piper and Embraer.

There are several factors worth mentioning which helped Embraer in learning new technology and business in general aviation. Embraer has great access to the Latin aircraft market due to both its location and cultural similarity, which many aircraft manufacturers lack. Embraer also has reduced production costs due to cheap Brazilian labor which improves their competitive pricing. The last two Brazilian factors greatly help Embraer in particular: an abundant steel supply and proven industrial capability (50:28). Although Embraer has made great progress in learning how to manufacture aircraft there are still several areas in which they are trying to learn and improve.

Embraer remains dependent on foreign companies for key components. They have not yet become completely capable of total independent aircraft manufacture, but progress is being made (50:40). Many of Embraer's aircraft are currently designed, engineered and built in Brazil by Brazilians; however, Embraer still has to import a significant percentage of parts for each aircraft. Many of these items come from multinational corporations. Of

particular importance are turbine and jet engines from Pratt-Whitney, Rolls-Royce and Garrett (50:38). From an economic view the high costs of technology acquisition are being offset by increased export earnings and employment as managerial and personnel improvements increase throughout manufacturing and design (50:41). As long as economic benefits continue to occur Embraer will be able to continue its acquisition and growth of technological expertise.

3.2.5 Current Market. Embraer's initial success in the domestic market was an even greater success than some would have expected. By 1979, almost 90 percent of all aircraft acquired in Brazil were of significantly national origin. However engines for these aircraft, avionics and larger size aircraft are still widely imported (50:23). This initial success did not immediately result in Brazil earning foreign currency and reducing the debt because Piper retained an option to use its international distribution system for any exported aircraft based on an original Piper model (7:31). However, the technology gained did enable Embraer to design and manufacture transport aircraft for military and domestic markets. These aircraft have been widely acknowledged successes.

This success is so great that Embraer can consistently offer U.S. customers its passenger aircraft at a more attractive price than the U.S. can manufacture a similar

aircraft. This is particularly interesting considering the fact that Embraer is still dependent on U.S. aircraft engines (66:87). This success was publicly recognized when Fairchild Aircraft Co. filed a petition with the U.S. International Trade Commission (ITC) in an attempt to eliminate Embraer as a competitor in the U.S. market. The allegation was that Embraer constituted unfair foreign government trade practices. A complete investigation was held and the ITC found that Embraer aircraft were chosen over Fairchild because of:

- superior reliability
- comfort for passengers
- availability
- greater fuel efficiency
- better looks
- nonpressurization feature

Although Embraer also had a lower price, no unfair trade practices were found because the aircraft were different and Embraer would still be preferred at the same price as its competitors (50:35,36). In short, a branch of the U.S. government officially and legally certified that Embraer made a better product than a U.S. manufacturer and confirmed indications from the aircraft users' market.

To protect its potential selling market, Brazil has been careful about using U.S. products in arms and aircraft which it may wish to sell abroad. This is why freedom from export restrictions is of paramount importance to Embraer. In all new joint ventures there is a provision permitting

export sales to third party countries. This is why Rolls-Royce engines are in the new Embraer fighter (AMX) aircraft instead of a United States engine (50:30). When the identity of Embraer's customers is taken into account it is easy to see the reason for this: Iraq and Libya are Embraer's two largest transport aircraft customers and they both pay in oil (50:34). This helps Brazil gain both oil and currency needed to continue its national growth. Embraer's freedom from restriction is necessary to continue its current aircraft export policy which is export for cash; politics may be considered later.

Embraer's latest export aircraft is one the Brazilian Air Force uses. The turboprop EMB-312 Tucano trainer can be easily converted into a light attack aircraft (50:33) {see Appendix B}. This aircraft was designed as a replacement for the aging Cessna T-37 trainer aircraft used by many countries around the world (85:30). The Tucano has been bought by Brazil, Britain, Venezuela, and Egypt and has become the primary jet lead-in aircraft for those countries, according to Embraer's North American marketing office. Embraer's first export Tucano trainers are to be delivered to Britain in December 1986 (31:31). Currently Embraer is jointly developing the AMX fighter for both domestic use and export {see Appendix B & Section 4.5}. This aircraft will carry more than 8,000 pounds of external

stores and have a range of more than 1,250 miles (83:29). The AMX could then be highly competitive with other light military aircraft and if the Tucano is any indication, very successful on the international arms market. This success in the aircraft markets coupled with continued technological growth and independence makes Embraer's current and future prospects worth examining.

3.2.6 Future Prospects. The future for Embraer and its suppliers in the Brazilian aircraft industry looks bright. Domestic demand for aircraft has remained relatively stable and foreign (export) demand for Embraer aircraft has continued to grow since 1980. In 1981, export aircraft accounted for 43 percent of the company's earnings. Embraer is producing aircraft to meet this demand and continue its earnings growth. As of 1983, Embraer was producing over 40 aircraft per month in 11 types of 50 different models in its plant at Sao Jose dos Campos Brazil (50:32). Embraer's total sales are shown in Table 1.

The biggest problem in Embraer's future is its reliance on imports of some components which indicates a lack of total control over its current production and development future (36:296). If Embraer is able to sustain its technological development this problem may be overcome. This could be difficult because many of these

imports are currently helping support Embraer's joint ventures. If Embraer attains control over its production and supply its future could be even brighter.

TABLE 1

Embraer Unit Sales, Domestic and Export (64:16)

Model	Domestic sales	Export Sales	Total
Bandeirante	209	225	434
Xingu	53	47	100
Piper models	1807	--	1807
Ipanema	471	13	484
Xavante	166	16	182
Tucano	* 26	** 500+	26
total	2732	801+	3033

\* More on order and being delivered.

\*\* Total number ordered not yet delivered (94).

\*\*\* Illustrations in Appendix A.

The development of Embraer shows a need for U.S. corporations and the government to reorient their attitude toward involvement in newly industrialized countries like Brazil (7:13). Any benefits the U.S. could receive from an aircraft or arms partnership with Brazil would outweigh U.S. costs only if an agreement could be reached as equal partners, and not as a method for the U.S. to gain strong-arm control (66:81). This new orientation need not mean an exclusion of U.S. enterprises. Instead it could be a new opportunity for U.S. sales of equipment, services, components and materials through and to the Brazilian aircraft industry and most notably Embraer (7:13) Given

time and a reorientation of some interests, a strengthened partnership could provide benefits on both sides of the equator.

3.2.7 Summary. Although the Brazilian national aircraft company, Embraer, was established relatively recently in 1968, its growth as an industrial concern has been impressive. The Brazilian Government was able to recognize the need for a domestic aircraft industry and to act to establish both the company and an environment necessary for its initial survival and growth. The first major cooperative project, Xavante, provided the initial aircraft capabilities in 1970 and then these capacities were expanded with F-5 assemblies in 1973. During its joint venture with Piper corporation, from 1974 to 1984, Embraer was able to acquire more of the technological capabilities necessary to become a general aircraft manufacturer. During its most recent years, Embraer has become a major aircraft company in its own right covering all aspects of the aircraft industry from design to sales and support. The Tucano trainer is a good illustration of Embraer's capabilities. Embraer has even become more dominant in parts of the aircraft industry than its original mentor, Piper. Embraer does have some concerns for the present and future but it appears that these are not insurmountable. From nonexistence to a world class general aviation

manufacturer in twenty years, Embraer is a world class industrial success story and has a very bright future.

#### **4. Findings on Brazilian-U.S. Cooperation**

##### **4.1 Introduction**

In examining the prospects for a supersonic fighter and its future potential, one aspect of the current arms market becomes very clear: Asia, Africa and Latin America have become very competitive arms markets in all aspects of modern weaponry. Brazil, a western capitalist country, is moving to expand its arms production in all areas. If the United States does not provide Brazil with new weaponry and technology other countries will (27:46).

The area this report is concerned with is aircraft. Embraer's technical director, Guido Pessotti, reports that in expanding this sector of production Embraer is studying four main areas for new investments. The total investment would require approximately \$2.3 billion if all were attempted at once. First, there is a \$1 billion supersonic military aircraft project with air-to-air missiles to complement the AMX. Second, a subsonic jet trainer with an investment cost of \$500 million. Third, a turboprop passenger aircraft to carry 80 to 140 passengers at a development cost of \$600 million. Fourth, an improved version of the Bandeirante passenger plane at \$200 million (35:6). Due to financial and industrial limitations Embraer does not expect to do all four at once. Osires Silva, President of Embraer, says it would be possible for Embraer

to undertake two of these projects in the near future with the most likely projects being the supersonic military aircraft and the large passenger turboprop (35:6). This thesis is concerned with that supersonic fighter project.

Brazil's Air Force Minister, Octavio Julio Moreira Lima, is interested in replacing his Mirages and Tigers near the end of the century with a Brazilian made aircraft (41:10), so he initiated the supersonic fighter project. Brazil currently intends to build an Air Superiority Fighter based on specifications being studied by the Brazilian Air Staff requirements branch (28:M01). These studies are currently ongoing and are not released to the public.

The Brazilians expect to have the supersonic fighter-interceptor built by Embraer with a foreign partner. In the 1990's the Brazilian Air Force will replace its current tactical fighters with this plane (90:4).

To build a supersonic plane beginning at the end of the decade Embraer will need a new partner to substitute for the Italians whom it has outgrown. The Italians have no supersonic fighter. One problem is that Embraer President Osires Silva currently sees U.S. restrictions as 'radical.' But U.S. companies might be good partners if restrictions on reexport can be negotiated (63:10). Most

other factors lend themselves to cooperation and are presented here.

#### 4.2 Aircraft Design Factors

Currently aircraft design capacity factors do enable Brazil {Embraer} to be a full partner in an aircraft development project.

4.2.1 Embraer Capacity. Embraer's role is that of an aircraft manufacturer commonly referred to as an airframe manufacturer. It has capability in all fields; structures, aeronautics, systems integration (both mechanical and avionics areas), propulsion integration, equipment/subsystems specification and technical procurement (9:1). Embraer has all the necessary skills to design and manufacture aircraft. However, Embraer does rely on subcontractor support as do U.S. airframe manufacturers.

The technical areas in which Embraer could produce the most are primarily avionics, weapons system design and test and total system design responsibility. It also has a great deal of experience with integration, structural design, and subsonic aerodynamics design (9:1). Although Embraer already has a variety of skills it is still working to expand them.

Embraer recognizes that many new technologies will be

critical to its success in the aircraft industry in the future. Recently Sikorsky signed an agreement with Embraer for the transfer of composite materials technology. To use this technology Embraer is building a major facility for the production of composite parts to be used in the Brasilia, the AMX and the future supersonic fighter project (64:20). Embraer is also using today's technology in the design and production of its current aircraft.

Embraer has had its own CAD-CAM (computer aided design-computer aided manufacture) system since 1980. These design tools have been used extensively in aircraft structure and system design (drawing and engineering). This type of tool helps expand the engineer's productivity significantly. The CAD-CAM system is now undergoing capacity expansion in quantity as well as quality (9:2). Most of this equipment is state of the art and much of Embraer's CAD-CAM equipment is of U.S. origin (34:2-5). In several respects Embraer's design capability is very modern.

In the more traditional avenues of design Embraer does have a large-scale subsonic wind tunnel capacity for its use (34:2,5). Techniques like computer simulation have been used by Embraer when they thought it necessary (9:2).

For fabricating designs and prototypes, Embraer's production machines and tooling are also comparatively

new. These tools include technically advanced numerically controlled milling equipment. The capabilities also include Honey-comb, metal-to-metal bonding and composite materials and they are widely utilized by the company (32:6). Many of these techniques were learned when Embraer made vertical tail assemblies and pylons for the F-5E. These parts were exported to the U.S. as part of the offset agreement under which Brazil bought F-5's for its Air Force (55:26). These capabilities remain in use today in Brazil's manufacturing of its current line of aircraft.

Using the current capacities of the company's design capability is reflected in the workforce also. Of the company's personnel, Embraer has over 25 percent of its people in engineering design activities (34:2). Embraer's technical department, which does the development and design work, has over 450 fully qualified engineers in its cadre (9:2). Embraer is also investing in expanding its design and technological abilities and is spending on the order of US \$20-25 million per year, representing spending of about ten percent of its sales revenue on research and development (64:23). While this is not a great amount of money compared to what the U.S. Air Force spends in total; a 10 percent share of revenues is substantial and does indicate a serious commitment to the future development of the company.

**4.2.2 Partners' Capabilities.** The technical areas in which Embraer could benefit most from a corporate partner are supersonic aerodynamics, propulsion, digital flight control systems and fighter cockpit design for displays that minimize pilot workload (9:1). These are areas where several U.S. and European companies have considerable design expertise.

Currently the facilities are lacking for a supersonic fighter design project. Brazil does not presently have any supersonic wind tunnel facilities. To correct this problem the Brazilian Aerospace Technical Center (CTA) is entering a program to acquire such facilities. In this case, or similar cases, Embraer contracts for work and facilities outside of the country. Some of the facilities that Embraer uses are from CTA which is located near the Embraer facilities (9:1). The USAF has extensive wind tunnel facilities at Arnold AFS in Tennessee, and smaller facilities at the Air Force Academy, and Wright-Patterson AFB in Ohio in addition to the facilities at several defense contractors.

In the current production of aircraft in Brazil, foreign technology remains very important. The avionics for Embraer's new Brasilia passenger aircraft came from a unit of Rockwell. The number of defense related companies with factories in Brazil is so great that Sao Paulo can be

described as a junior military industrial complex, similar to larger complexes in Europe and the U.S. (90:5). This extensive interaction of companies with Embraer would be very good in reducing the amount of training which would be necessary in a joint fighter project.

4.2.3 Training. The training necessary for maximum cooperation among partners with Embraer would be minimal for two reasons.

First, Embraer has had a very broad interaction with many American companies during the last fifteen years. These companies range from aircraft vendors and manufacturers to operators. This would indicate that no training and education is needed for the Brazilians to cooperate successfully (9:2). Some cultural sensitivity training may still be appropriate for Americans assigned to such a program.

The second circumstance which fully favors cooperation between the U.S. and Brazil is that Embraer's engineers already speak English. English is the formal language for the AMX technical relationship in the joint program with the Italians. English is also the language for technical documentation and reports issued by Embraer for the EMB-120 BRASILIA certification even for the Brazilian authorities (9:2). Since English is already the technical language for Embraer, communication difficulties should be minimal, even

if not totally eliminated.

#### 4.3 Aircraft Production Factors

Embraer does not currently have the industrial capacity to produce a supersonic fighter. However, they do have the industrial skills and training capacity with an available labor pool. Considering Embraer's willingness to expand capacity, this is rated as a positive factor.

The development of production capacity in all segments of the arms industry is important to Brazil. Brazil has not built huge stockpiles of weapons. It has chosen an alternative approach which emphasizes developing productive capacity and technology to be able to produce weapons quickly whenever necessary (8:73). Additionally the productive capacity of weapons is critical to profitability.

Cost competitiveness in aircraft manufacturing depends mainly on the volume of output of a manufacturer {see Appendix E}. Since this is a highly competitive industry, cost is a major concern. Therefore, companies strive for economies of scale and experience which effect the costs of engineering, manufacturing, sales and service (64:29). In this respect Embraer is no different from any other manufacturer. The costs on the new Brazilia, Tucano and AMX will depend mainly on unit volumes; so Embraer must

continue operating in a reasonably efficient way, because unlike other aircraft manufactures its unit costs depend on how well its planes are accepted by the market (64:30). With few exceptions, U.S. military aircraft producers have all their costs covered by the U.S. Department of Defense.

4.3.1 Numbers. The Brazilian aircraft industry does not have the industrial capacity to support such a project, but it is willing to expand its capacity as necessary.

Currently the only specifically military aircraft in production is the EMB-312 Tucano. The current production rate is five aircraft per month, but the line is geared in order to quickly expand to 7 airplanes per month. Embraer's plan for the AMX production line is for a normal five main assemblies by month, and two aircraft in final assembly. This is in order to satisfy Brazilian Air Force requirements. Additionally a 40 percent reserve capacity has been included in the line to satisfy export requirements (9:1,2). This capacity was built expressly for these programs and it is anticipated that new facilities would be built for the supersonic fighter.

Embraer is also producing civil aircraft at a rate of 11 aircraft per month, with over 3000 total aircraft produced since 1971 (34:8). This production includes seven different types of aircraft (34:17).

The unused industrial capacity which could be

transferred to this supersonic fighter project is very small and in a practical sense may be considered non-existent (9:3). In answering questions about productive capacity Embraer said, "Considering the years ahead before the occurrence of this program, it is difficult to make a precise forecast [of production facilities for a supersonic aircraft plant]" (9:3). However, Embraer indicates additional industrial capacity will be built for a supersonic fighter project, even though the present facilities are almost technically capable of production of a supersonic aircraft (9:3). So Embraer expects to build new facilities for a new product as it has in the past.

4.3.2 Skills. The production skill base for Embraer to expand on includes all the basic skills and facilities. Embraer has facilities for machining parts and tools, construction of assembly jigs, metal cutting and bending, metal-to-metal and honeycomb bonding, chemical milling, a full range of heat treatment capabilities and is acquiring composite manufacturing skills (13:8 & 64:20). Therefore Embraer would not have to perform the great task of acquiring skills but a relatively smaller task of increasing the skills it already possesses.

In setting up production facilities Brazil prefers to take its partners into account. They consider the ideal situation to be one of dual final assembly lines with each

country having a single source for main assemblies (9:3). This approach has been used in several multinational aircraft programs. Embraer has had experience with this type of arrangement in licensing Tucano production in several countries and in the development of the AMX aircraft.

With this activity going on, Embraer was approached to participate in a helicopter project with Sikorsky. The design capacities were in full use with the Tucano, AMX and Brasilia projects, so Embraer did not want to enter into any new projects at the time (64:20). This new thrust to expand helicopter production in Brazil is receiving continued emphasis from the Brazilian government (84:10). When these projects are completed Embraer will need a new project to work on as its design and production capacity becomes free and the company strives for more growth. When this happens Embraer will have the capacity to enter into a supersonic fighter project. This would expand Embraer's product line with a complementary product and expand both its technical capacities and industrial production.

4.3.3 Labor. One of the best assets of the Brazilian aircraft industry is that the cost of labor is much lower in Brazil than in any other aircraft producing and exporting country. "Average manufacturing wages at Embraer were estimated at US \$1.90 per hour in 1984 as compared

with \$11.85 in the U.S. airframe industry in 1982" (64:29). This low wage rate enables Embraer to hire the necessary personnel without incurring the additional financial burden which would be realized in another industrial nation. The aerospace industry of Brazil employs approximately 16,000 skilled and specialized people. This includes the 300 subcontractors and R & D organizations on which Embraer depends. Embraer itself employs 7,645 people in its aeronautical activities (32:2). These people are new to the high technology industry of aircraft manufacture and require a great deal of training.

The training that Embraer gives its employees is extensive. This training also costs the company proportionally more than other aircraft manufacturers spend on training. This expense is repaid by a greater and higher worker productivity. The personnel are motivated and in many cases were attracted by the educational opportunity and training available at Embraer (32:6). The labor force is also compensated in an equitable manner. Embraer offers benefits that are competitive in scope to those available in other countries. These include: "subsidized medical care, group life insurance, inexpensive cafeteria meals and bus service, 30 day paid vacations and a country recreation center open to employees and their families" (32:6). Due to these progressive labor treatment

and compensation policies Embraer has been free of any disruption of production due to labor disputes (32:6). That is a very good record in a country where labor disruptions are almost an everyday event in some part or industry.

Today Embraer's workers are still producing aircraft at a steady rate. They have produced over 3,240 aircraft since the company's founding 17 years ago (33:23). These aircraft have been meeting customers' needs and there is every reason to expect them to continue to do so in the future.

#### 4.4 Aircraft Operations Requirements

The operational needs of the Brazilian Air Force are not as stringent as those for the USAF tactical fighters; but are well within the capacity of several U.S. companies. Therefore, this factor favors contractor cooperation but not USAF operational use of the aircraft.

The recent Falklands War disrupted the peaceful tranquility of the South Atlantic and has forced the Brazilian military to reconsider its traditional role of internal security. The close observation of Argentina carrying out a full scale war against the United Kingdom has reinforced the need for Brazil to develop its own military industrial capacity (42:27). This means that the Brazilian supersonic fighter project must meet the needs of

the Brazilian Air Force.

The Brazilian Air Force does not wish to release the specification for their supersonic fighter project to the general public. The Brazilian Air Force is still in the process of defining the requirements for the supersonic fighter project and the specification may be misleading about the final form, while trade off studies are still being completed. The requirements for the fighter project come from discussions with Embraer and from the fact that this plane is to replace the F-5 and Mirage III and most likely would follow the basic philosophy of Brazilian weapons design. Therefore the requirements for Brazilian fighter aircraft are similar enough to recent USAF aircraft to make this project well within the capacities of the U.S. aerospace industry to fulfill a partnership role.

4.4.1 Performance Factors. In looking at the requirements for a Brazilian supersonic fighter, the Brazilian Air Force desires a fighter aircraft which could meet its own needs and be exported successfully to the Third World and possibly China. The aircraft must be "affordable and cost-effective in order to satisfy Brazilian Air Force budget and requirements" (9:3). This leads to some basic desired performance requirements.

The top velocity for this supersonic fighter should be approximately MACH 2.0 (9:3). This is twice the velocity of

sound and would make this fighter aircraft competitive with all but the most advanced fighter aircraft of the superpowers. The Brazilians are also looking for state-of-the-art maneuverability in their fighter aircraft (9:3). The current state-of-the-art for fighter aircraft is limited by pilot endurance, not by aircraft design factors. This would mean that the Brazilians expect their fighter to be competitive with all current aircraft in this performance factor and be able to achieve a +9 G and -3 G in high performance turns. This flight performance would give the Brazilians a very capable aircraft.

In addition to outstanding flight characteristics a fighter aircraft also must be adequately armed. Embraer has indicated that currently the armament of the fighter should be 2 short range air-to-air infrared missiles plus 2 to 4 medium range, air-to-air missiles, with "over the horizon capability" (9:4). The two short range missiles would probably be AIM-9 Sidewinders or Brazilian Piranha or European ASRAAM missiles. The four medium range missile would most likely be AIM-7 Sparrow or AIM-120 Amraam missiles from the U.S. or very similar missiles. In addition to this armament the new Brazilian fighter would also have an air-to-air gun capacity of the 20mm or 30mm class. The avionics and ECM and ECCM equipment of the new fighter could have a great many variations and it is too

early to tell what these requirements might be.

4.4.2 Logistics Factors. Many authors have questioned the use of high technology weapons systems outside of the superpower sphere of control. The question of the overall appropriateness of the weapons has been continually criticized. Do they really add to military capability, or are they just prestige weapons? Should a country buy five F-5's properly absorbed, operational, and fully employed, or one F-15 grounded for parts with a marginally competent pilot (55:45)? The answer to this question is that a weapons system is only as good as its training and logistics support.

The Brazilians have been very attentive to the logistics requirements of their weapons. This philosophy is stated very clearly by Jose Luiz Whitaker Ribeiro, Founder and Chief Executive Officer of Engesa, the world's largest manufacturer of wheeled military vehicles, who said "We make our vehicles so our own soldiers can understand how to maintain them. They don't even have to be able to read. We give them 120 video cassettes that show every step they need to master the machines" (61:25). This is not just a statement of a goal to be reached or a desired state of affairs. The Brazilians have built a very good reputation which comes from the equipment itself being easy to logically support.

For the supersonic fighter project the Brazilians intend to follow this same basic approach and will avoid having any special logistics procedures or activities. In Embraer's opinion there are to be no special logistical constraints on this type of a fighter project (9:4). The aircraft should be easy to maintain by Brazil or any of Brazil's potential customers. The supersonic aircraft should have a mean maintenance man-hour per flight hour, of around 15 maintenance man hours per flight hour {MMH/FH} (9:3). This is a very good goal because a very low level of attention would be necessary to keep this aircraft operational in comparison to many modern fighter aircraft.

As for the logistics systems required for this maintenance there would be very little adjustment necessary for the U.S. and Brazil to work together. Even though the Brazilians recognize that the US and Brazilian Air Forces (FAB) have unique requirements they do not believe the differences will be difficult to overcome. This is because the FAB is currently flying U.S. C-130E and F-5 aircraft. The Brazilians have also become familiar with several NATO requirements through their involvement with the Italians in the AMX project (9:4). So, the differences between the performance and logistics considerations of the two countries appear to be minor but, the same cannot be said for the business concerns.

#### 4.5 Selected Business Concerns

This supersonic fighter could generate large amounts of export and Brazilian sales in the low cost end of the fighter market. Coupled with the large financial load this project lends itself to the use of a joint venture partner{see Chapter 5 and Appendix E}. The current U.S. control of high technology exports works against such a project and appears to be the limiting factor.

The Brazilian defense budget in 1984 was only US \$2.3 billion accounting for .6 percent of the GNP (85:53). The United States defense budget during the same period was about \$280 billion dollars (105:335). Therefore the defense industry and business which could be sustained by Brazil alone could be expected to be proportionally smaller. So much so that Brazilian Admiral da Fonseca stated "Brazil can not maintain a war material industry for the Brazilian armed forces alone" (4:14-15). This overall limitation applies to military aircraft as well since this is one segment of the defense industry.

The Brazilian aircraft market is too small to sustain a growing and internationally competitive company, as Embraer strives to be, for the long-term (64:24). Even with this small market a Brazilian General explained that the activity in the arms industry is caused by two factors.

First, Brazil's perceived need to modernize its equipment following the Falklands war. Second, the opportunity to earn export dollars (51:6). Without the need to modernize arms, the government may not have encouraged the arms industry; and without the earning of money from the business the arms could not have been afforded. This works as a two fold reinforcement of the business.

As it was explained in the Latin American Times,

"The rationale behind this extensive Brazilian participation in the international arms market is not hard to identify. In the first place, increasing tensions throughout the world, associated with the continuing growth of populations and the resulting strain on economic resources, implies a market of extraordinary depth, with endless opportunities for replacement orders. Secondly, Brazil's status as a Third World power enhances sales prospects among developing countries. Finally, of course, there is the lure of hard currency payments. Traditionally, arms transfers are paid for in hard currency- cash on the nail, deferred payment arrangements being the exception rather than the rule" (13:8).

The rationale, then is one, a demand for armament; two, Brazil as a friendly country; and three cash money to Brazil.

4.5.1 Markets. The Brazilian arms industry is aimed at Third World buyers. The Brazilian success in this approach has been so great that the Brazilians predict their arms sales will total US \$10 billion during the next five years (61:25). The importance of export customers is apparent when the Brazilian arms industry exports 95

percent of its production (15). This export driven industry with its customer's particular needs has made Brazil adopt a particular approach to weapons. The Brazilians insist that their arms be simply designed, easy to maintain and low priced. These three factors are causing Brazilian arms and aircraft to be increasingly visible on world markets (41:8). Some people have derided Brazilian produced goods because they are not as sophisticated as many U.S. produced weapons. In fact because they are not "technical marvels" the products sell very well since they are simple and can be more feasibly acquired and operated by Third World countries (18:1).

Brazil has also profited from some political restrictions of the United States. Brazil has sold weapons to several countries after the U.S. refused to sell arms to those countries (88). The Brazilians moved in and sold the countries arms in spite of the United States.

Since the Brazilians are building largely for export, offering simple, easy to operate, low priced equipment was a good idea in the 1970's and early eighties. This marketing approach led to a growing market share, increasing number of customers and increased revenues and industry expansion. This approach is an even better idea in the late eighties with the plummeting price of oil. Because of declining oil revenues, many major Middle

Eastern arms buyers are likely to "prefer well built Chevrolets to Cadillacs" and it is this kind of weapon Brazil offers. Added to this advantage is a growing complaint that First World weapons technology is too complicated for the Third World soldier" (41:11). The growing market for cheap easy to operate aircraft and arms is to Embraer's advantage.

Since the Bandeirante, all of Embraer's aircraft have been designed for the export market. The Tucano trainer was designed under contract to the Brazilian Air Force but with the same type of features for the domestic military which would be desired in an export aircraft. Since the introduction of the Tucano, foreign customers have been courted aggressively, with help from the Brazilian government. Embraer has already agreed to license manufacturing of the plane to a U.K. manufacturer {Shorts Brothers} in order to win a large order to provide income to Embraer (64:28). The export of the Tucano has been Embraer's commercial export success to date.{see Section 4.6}

The Brazilians are reported to have exported military equipment to over sixty countries (93). The Brazilians have carefully targeted their marketing to meet two factors. First was to sell to countries which had a demand for Brazilian products- with no strings attached. Secondly,

these customers also had materials needed by Brazilian industry (4:16). The most notable material has been petroleum. These factors have resulted in the Middle East and Africa being the primary trade partners with weapons exports helping to balance Brazil's trade account with imports of oil and exports of arms (41:10). In this context it is not surprising that Iraq has become Brazil's largest single customer since the start of the Irani-Iraqi war (81). In addition to economic factors, cultural and geographic factors have also helped Brazilian arms exports making Latin America a large market for Brazilian arms (8:74). As a result, Brazil's current primary markets of the Middle East, Africa and Latin America appear to offer a market for a Brazilian supersonic fighter aircraft. Many of these countries do not wish to purchase arms from the U.S.S.R. or the U.S. and the U.S. and U.S.S.R. do not wish to sell to these countries because of use and sales restrictions or logistical or political problems. Therefore, this market seems secure for Brazil in the near future.

The Brazilians, especially Embraer, are seeking to expand the markets for their products outside of their current clientele. Several countries like India, the Peoples Republic of China, and even Argentina rely on large military forces that need to be armed. In many of these,

purchases price will be a factor. In many situations short of actual war, these mass armies can be impressive and intimidate a nation's neighbors. "So these armies, navies, and air forces may represent significant export opportunities for cheap, serviceable weapons" (55:10,11). Toward this end Embraer has been participating in more international aerospace shows, including one coming up in China, and holding more promotional events of its own.

#### 4.5.2 Possible Business Partners and Competitors.

Embraer has been examining several aerospace firms around the world for possible business partners on the supersonic fighter project. Although many companies have the technical capacity, as previously discussed, some companies hold more promise than others. The companies mentioned most frequently for partnership with Embraer in a supersonic fighter project are British Aerospace, Marcel Dassault, Pratt & Whitney, General Dynamics and Northrop.(90:4,6 & 28:M01 & 41:9) Although many choices could be made, some considerations are already apparent.

Pratt & Whitney {of Canada} is almost a sure partner in the propulsion aspects of the design project due to their extensive working relationship with Embraer in the past. However, Rolls Royce has gained a foothold in its prospects because of its role in the current AMX program. If Rolls Royce's engine does not perform up to expectations

in the AMX, the selection of Pratt Whitney would be assured. General Electric's (GE) possibilities for participation in this project appear to be smaller. GE is wholly in the U.S. and therefore completely subject to U.S. export control laws. The market risk and returns and cooperation means GE probably would not make the effort to become a supplier to a Brazilian supersonic fighter program until the technology export issues were fully resolved.

Of all the companies mentioned for a partnership in the supersonic fighter program, only British Aerospace has made a public statement of commitment. The president of British Aerospace, Sir Hugh Metcalf, has proposed to the Brazilian Air Minister, Octavio Julio Moreira Lima, that the two countries work together in building a new supersonic fighter plane. "The British proposal offers the license for production and sale of an agile combat aircraft to compete with the Messerschmitt Bolkow Blohm TFK-90 made by West Germany, for producing what could become the standard European fighter plane for the decade of the 90's and the beginning of the 21st century" (1:16). This is understandable since Northrop {with the F-20} and General Dynamics {with the F-16} and Marcel Dassault see themselves as having a fighter which meets the needs of the fighter market to be targeted by the Brazilians. Overlooked by the press are McDonnell Douglas, Lockheed and Grumman. All

three may be better prospects for cooperation with Embraer. None of these three companies have fighter aircraft in the low cost end of the fighter market and this would help expand their product lines. Also, all three have the technical, financial and managerial strength to contribute in this project. Since British Aerospace naturally wants to expand its presence in the market place it could be expected that they would be the first to see advantages in such a program. In considering partners one must also consider who the competitors would be.

The growth of sales in Brazilian armaments and aircraft has been so great that Brazil may soon compete with Great Britain or France to be the world's third or fourth ranking weapons exporter (91). The French are now concerned with reports of negotiations looking toward a US \$3 billion arms contract between Brazil and Saudi Arabia to supply aircraft and arms. France even appears to see Brazil surging ahead as a competitor (54). While the U.S. companies often have their military aircraft expenses covered by the U.S. government with export sales providing additional profits, their competition may not be as severe as competition from other countries. French and British companies count on exports for a substantial part of their revenues. Since the British have already offered to help Embraer we may expect Embraer's stiffest competition to

come from the French company of Marcel Dassault. In possible competition from the U.S., Embraer faces Northrop and General Dynamics. Northrop does not seem to be able to sell their F-20 to anyone, so this threat may be questionable. General Dynamics has been highly successful in F-16 aircraft sales with flexible sales terms. Embraer will have to keep its supersonic fighter's price in the range of 10 to 15 million dollars to keep its traditional cost leadership marketing role.

In associating with companies from other countries, Embraer has a preferred mode of operation. The Brazilians prefer to operate in a government-to-government mode under a "Memorandum of Understanding" with contracts between the companies taking place within the governmental framework which would be laid out. A direct commercial venture is much less preferable to Embraer since it leaves the ultimate customer out and may lead to a costly misunderstanding (9:4).

#### 4.5.3 Brazilian Government Interests and Financing.

To come to an agreement on the governmental export and import agreements, the positions of both the United States and Brazilian governments must be considered. Since these two countries have different views on the export of weapons, the superposition of these policies probably would complicate problems in reaching an agreement. A solution

to this could only be attained by a negotiation and agreement between the two governments (9:4). U.S. foreign military sales procedures have been well documented, so the focus here is on Brazilian sales policies.

One of Brazil's foremost industrialists outlined Brazil's export policies informally in contrast to one of Brazil's competitors. Jose Luiz Whitaker Ribeiro, Chief Executive Officer Engesa, said "With Brazil no political strings are attached to arms sales. When the Russians make a sale, they come in with 600 technicians, build a base and start to meddle in your country. Brazil makes a straight commercial deal and we even give a year's guarantee" (61:25). Even though this statement does over simplify it a bit, the statement does express the attitude of the Brazilian government in exporting arms.

After an arms sale is agreed on between a customer and a Brazilian company, like Embraer, the arms sales proposals are presented to Brazil's National Security Council for approval. This governmental council, made up of government ministers, weighs political, diplomatic, military, and economic aspects of how an arms sale affects Brazil before reaching a decision. "Among the diplomatic and political considerations advanced as policy are the following: negotiations are undertaken on a government-to-government basis; sales to guerrilla or subversive groups are not

considered; sales are not made to countries on the brink of war where the export of arms could influence the commencement of hostilities; exports of arms to unstable governments or those with unsavory reputations are avoided" (11:85,86). However these decisions are considered on a case by case basis and an exception to one of the criteria may be made if the overall sale helps Brazil (11:86). For example, Libya is a main customer. Brazil exports their weapons primarily for commercial gain for Brazil with political factors being a secondary consideration.

To gain approval for a supersonic fighter project in Brazil would require the approval of the Brazilian government. "By statute, any of Embraer's new projects must be approved by the government" (9:4). This approval would be necessary for the start of any joint supersonic fighter project regardless of the partner for Embraer. Embraer is even more tightly controlled than this fact would indicate. Although government ownership of stock has declined the Aeronautics Ministry still controls the majority of voting stock in Embraer. Through government regulatory power the Aeronautics Ministry also controls the domestic market for both civil and military planes. With this control has come an assumption of responsibility to act in the best interests of Brazil as a whole. Because of this responsibility the government has been reluctant to

invest in projects with unattractive commercial prospects, and has forced Embraer to depend on its own resources for civil projects (64:38). This has placed Embraer on a very tight financial budget. However, the Brazilian government has used the leverage of market access to entice foreign companies to assist Embraer in developing technology (64:24). This has met with varying degrees of success, and as Embraer's dominance of the domestic market has grown this leverage has declined. The government is now moving into financing military projects in a manner which is typical in the United States.

Embraer will now do preliminary work on the design and prospects for a new military aircraft. If the work is promising, Embraer will make a proposal to the Brazilian Air Force. Then the Air Force signs a contract with Embraer to work on the detailed design of a proposed plane and to come up with cost estimates. If this work is accepted and the project is needed then the Brazilian Air Force funds the development of the plane and the first prototype (64:31). After the production line is functioning, export marketing starts. The Brazilian government provides export financing for arms and aircraft (82). This is very similar to some of the financing programs of the U.S. government in FMS concessionary sales, FMS credits and Export Import Bank activities. In Embraer's activities, foreign bank

financing, unimportant in the early years, is now the most important source of outside funds (64:31). The distribution of Embraer's development funds is now limited and is allocated to the most promising projects.

Embraer is studying four new investment projects. The four projects could require approximately US \$2.3 billion total investment. Brazil can not afford to do all four at once. The most important is a US \$1 billion supersonic military aircraft with air-to-air missiles which would be complimentary to the AMX. The next in importance is a turboprop passenger aircraft to carry 80 to 140 passengers and cost about US \$600 million. Some models similar to the Embraer proposal are in development in other countries. The third most likely project is an improved version of the Bandeirante passenger plane. This needs a relatively small investment of US \$200 million. The last project is a subsonic jet trainer that would run in the range of US \$500 million in development costs (35:6). The President of Embraer said that work on the supersonic fighter project and the large {80-140} passenger turboprop are in the foreseeable future (35:6). These two projects would expand Embraer's product line and could be expected to expand its revenue as well.

Recent Brazilian economic growth has been great, and as one source stated, "The Brazilian arms export explosion

is a part of a drive for economic growth which places Brazil in the category of newly industrialized countries such as South Korea, Taiwan, Hong Kong and Singapore" (41:10). This export explosion can be expected to improve Brazil's financial position. Brazil's US \$100 billion foreign debt, requiring annual interest payments of US \$10 billion, is a strong motive for the expansion of all exports including arms (41:10). As a result, the Brazilian concern and emphasis on business aspects of the arms industry can be expected to continue into the future.

#### 4.6 Current Activities

There are currently no joint military aircraft projects between the U.S. and Brazil (9:4); however, Embraer has done a great deal of work on military aircraft projects. Embraer's experience in this area led the Brazilian Aeronautics Ministry to begin working with the company in the late seventies on ideas to replace fighters in the Brazilian Air Force fleet (64:17). The Aeronautics Ministry (which is the Brazilian Air Force) wanted to support a Brazilian aircraft manufacturer, especially one in which it had a substantial stake. So the ministry has directed its order to Embraer for anything that Embraer can produce and manufacture in country at a reasonable cost (64:27). This policy could help develop Embraer and use government funds to help stimulate the economy instead of

exporting important cash reserves.

The importance of the military aircraft market has grown. By the 1980's the development of the Tucano trainer and the AMX fighter for the Brazilian Air Force has placed a good portion of Embraer's future revenues in the military aircraft sector (64:27). Both of these projects are multinational in scope and so they will be described here: the Tucano trainer program, currently in production; and the AMX program, currently in development.

4.6.1 Tucano. The Brazilian Air Force had a need for a trainer aircraft to replace the Cessna T-37 which was nearing the end of its life. The desire was for the airplane to be a high performance plane that was low in cost and Brazilian made, so the Brazilian Air Force directed the project to Embraer (85:30). The development started in 1978 with the Air Force funding development under a development contract (64:17). The trainer that grew out of this project became the very successful Tucano turboprop trainer.

The Tucano has become the most advanced trainer aircraft in its category and is operating in several countries. Among the features of the aircraft are (95:2):

- maximum speed 550 km/hr
- single accelerator/pitch control for speed
- double (complete) instrument panels
- fuel consumption of 30% less than other modern training aircraft

This trainer aircraft became a multinational program with the set up of production facilities in both the United Kingdom and Egypt.

The Royal Air Force of Britain was looking for a new trainer aircraft for jet lead-in training. In addition to the usual requirement for such an aircraft the British requirements included a 30 year guarantee of durability, the ability to reach an altitude of 150,000 feet<sup>5</sup> in seven minutes, and resistance to collision with birds (38:2). Since the Tucano was built for the role of a jet lead-in aircraft and the Brazilian build highly durable aircraft, the Tucano was an ideal competitor.

British Defense Minister announced to the House of Commons that, "The British Royal Air Force has chosen the T-27 Tucano designed by Embraer of Sao Jose dos Campos, Sao Paulo as its new two seater trainer" (77:6). In order to secure this highly competitive contract Embraer had to agree to a license agreement with a United Kingdom contractor, Shorts Brothers, with a separate management in Ireland made of U.K. personnel (9:5). The details of the agreement appear to be quite similar to offsets which the First World gave to the Third World in selling complex

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5. If this source is accurate, this indicates very high performance for a turboprop trainer, and a substantial improvement from the performance reported in Source 52.

expensive arms.

In this case it was the other way around with Brazil giving offset agreement to Britain. Embraer is building the first six Tucano trainers in its own plant while it trains the Shorts Brothers employees. The remaining 124 aircraft will be built in Belfast, Northern Ireland. Embraer is to earn a 5 percent royalty on each aircraft built by Shorts. This is a major sale with each aircraft carrying a US \$1,000,000 price tag plus development and set up costs (77:6). The first aircraft built was flown on January 14, 1986 and then test flown until March 21, 1986 when it was crated and shipped to the U.K. (21). This contract not only helped Embraer's balance sheet but also boosted its reputation and standing as an aircraft manufacturer around the world.

Embraer has also made a major sale of the Tucano to the Arab countries. A plant is being built in Egypt by the Brazilians to manufacture more Tucano trainers under a license agreement (9:5). Embraer has been rumored to be building over 200 aircraft for the Arab world with financing being provided by the Saudis. Although this is speculation and no factual evidence has been presented to the public, the truth should be known in time. The Tucano has also become a great success in export sales. Brazil sold 30 Tucano military trainer aircraft to Venezuela in

December 1985 in a deal valued at \$52.8 million (94). Still other sources report of over 500 Tucanos being sold throughout the world (43:22). Although the Tucano is already a certifiable success, the AMX aircraft is still in the developmental stage.

4.6.2 AMX. In addition to aircraft models that Embraer is already manufacturing, it is constantly in search of new aircraft needs. Embraer's latest development project is a joint aircraft development program with the Italians called the AMX attack aircraft (13:24). Although Brazil did buy, and is still flying, the F-5E from the United States, later desires to acquire licensing rights were frustrated and Brazil turned to development of a new domestic jet fighter, the AMX (86:29). Taking into account some of the unique concerns of the Brazilian aircraft market {Section 4.5}, this project provided an opportunity to both domestically produce aircraft and ensure access to foreign markets and reduce unit costs (64:28). The Italians had the same thoughts on the subject and Aermacchi approached Embraer with a proposal to work jointly. The AMX agreement was negotiated and then signed in 1980 (64:17). This started Brazil's first multinational modern military fighter development program.

The AMX program involves two Italian companies and Embraer. The partners have divided the work into shares

with the shares as follows: Aeritalia {46.7 percent share}, Embraer {29.7 percent share}, and Aermacchi {23.6 percent share} (33:20). These shares are divided along sub-unit lines with Embraer doing most of its work in the wings and engine intakes (33:21). Each contractor has separate management for its own main assembly. Each contractor is also responsible for the main assembly's performance, execution, and financial burden as divided along the management lines (9:4-5) {see Appendix B}. Although each contractor is the sole producer of its main assembly each country has an assembly line capable of final assembly of the AMX aircraft (64:21). Brazil also has an interest in the propulsion section in addition to the airframe.

Brazil has a responsibility for thirty percent of the engine work to be done in the production of the Roll Royce Spey engine that will power the AMX. This work will be performed by Celma, a company owned by the Aeronautics Ministry (64:17). The Aeronautics Ministry is seeking to help build up Celma to gain a complete aircraft production capacity in Brazil.

From the time the concept of a Brazilian fighter first started, the AMX aircraft has taken almost a decade to produce. The feasibility and definition phase lasted from January 1977 to December 1979. The development phase started in January 1980 and the first flight was in mid

1984 (33:20). The Brazilian AMX is scheduled to start production this year with the first deliveries to the Brazilian and Italian Air Forces in 1988 and 1989 (41:9). The number of aircraft on order from the Brazilian Air Force has continued to grow as the AMX program has met with increasing success. The initial order was for 60 aircraft and it has steadily grown to the present requirement for 140 aircraft (28:MO3). Embraer is expecting a similar increase in demand from export sales of the aircraft.

The AMX aircraft is priced to be very attractive to Brazil's targeted market of Third World countries. The current projected cost of the AMX is US \$10 million (85:32). This is well below the cost of other fighter aircraft on the market. To meet the projected demand for this low cost weapon Embraer is expanding. Additional production facilities have been constructed for the AMX and for the fabrication of parts made from composite materials used in the AMX (64:18). In addition to the attractive price, the AMX appears to be a capable airplane.

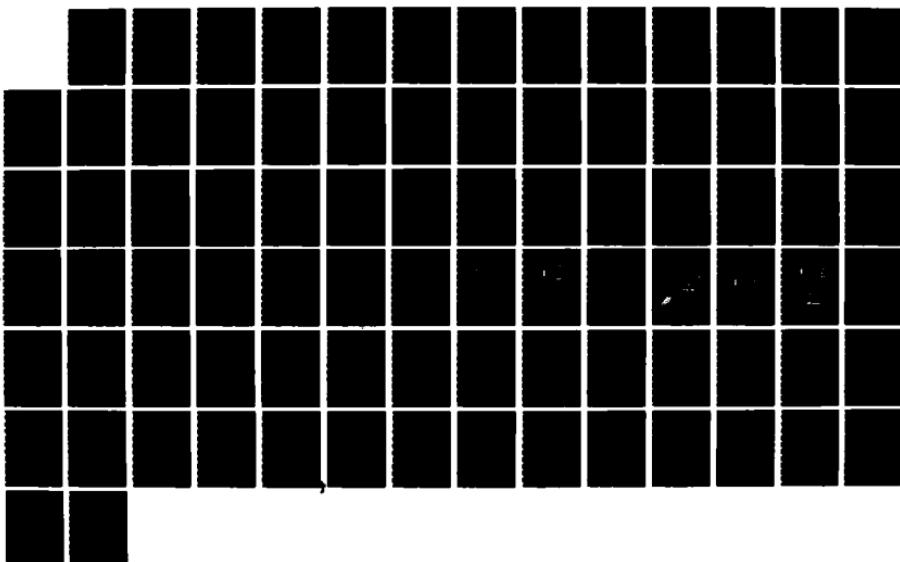
The prime task of an attack aircraft is to be able to accomplish interdiction against enemy ground forces (33:4). The AMX is designed for this task in terms of performance and features, future expansion and maintenance.

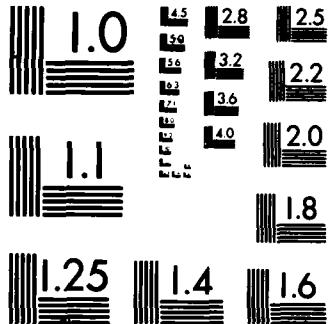
The AMX is able to operate day or night at low altitude at high subsonic speed {MACH .95} (33:6). This is

in the same speed range as attack aircraft flown by the USAF {A-10, A-7}. The AMX is designed for its prime features to be readiness, low vulnerability, high survivability and safety, and in-flight refueling (33:4). The overall design objectives are met by providing sufficient power from the Rolls Royce Spey Mk 807, a two shaft turbofan of modular design (33:14). All of the AMX subsystems are designed to assure the successful completion of the mission following a major failure to a major system (including simultaneous failure in both the flight controls and navigation/attack systems). Typically such a failure is induced by battle damage. This approach to system design ensures a safe return to base even after a second failure (33:6,7). The structural design of the AMX is also considered with a Multipath structures system. This enables structural isolation of damage and protection so the AMX can complete its mission. The weapons which enable the AMX to perform its missions were also carefully considered.

The AMX carries a variety of armaments. For attack, the AMX has 5 external stores stations which may be configured for any ammunition. The two exterior stations are limited to 1000 lbs each with the three interior stations limited to 2000 lbs each. This gives the AMX a total stores capacity of 8000 lbs. For self defense the

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REPRODUCTION RESOLUTION TEST CHART  
NATIONAL BUREAU OF STANDARDS-1963-A

AMX carries 2 wingtip air-to-air missiles (AIM-9 class) and internally a single 20mm VULCAN or dual 30mm DEFA guns at the client's direction. Embraer also provides the customer with a choice of radars (33:12). Even though this equipment should be adequate for most missions the AMX also has provisions for additions to be made to the aircraft.

The design includes a power surplus in electrical and hydraulic systems and spare internal volume to accommodate additional equipment which maybe required by future developments; for example, "new NATO identification and data transmission systems, JTIDS and NIS, GPS or NAVSTAR for precision navigation and even MLS can be quickly installed without affecting existing functions" (33:8). This provides the flexibility many customers demand in purchasing expensive high technology products. The concern for the customer's operation is also reflected in the maintenance aspects of the AMX.

The AMX is designed for easy access. There are more than 200 access panels for a 95 percent accessibility to the aircraft interior for maintenance. All are accessible with a maximum working height of 1.7 meters {approximately 5.5 feet} as shown in Appendix B (33:14). This provides for outstanding ease of maintenance which is rare in high technology fighters.

The AMX is an outstanding aircraft considering that it

came from outside the superpower's direct control. As Richard Foster, a noted correspondent on Brazil, said, "The Brazilians see the AMX as proof they have emerged into the electronics age and are now capable of producing weapons competitive in both price and performance with those produced in more advanced industrial nations" (41:9). Other countries appear to think so too. Besides Italy and Brazil, Embraer says four more countries, which it has not named, have expressed interest in buying the AMX (5:8). Embraer could have another success of the magnitude of the Tucano aircraft starting production within the next year.

Embraer is not new to the setting of multinational aircraft development and marketing and with the experience of the Tucano and the AMX aircraft behind them, lack of experience should not be a problem in any future cooperative aircraft program.

#### 4.7 Possible Future Actions

Embraer plans to examine all aspects of any possible joint organization before stating a preference for any particular division of responsibility and management. The environment and constraints that each partner would have in effecting Embraer would have to be taken into account. This situation is well represented by the different schemes and organizations encountered in Tornado, AMX, F-16,

Jaguar, and Airbus programs. So the question of what future actions would be necessary remains open (9:6). Although the option to initiate a supersonic aircraft program with the United States remains open, there are several trends developing in the future patterns of Embraer's operation.

Brazil and Saudi Arabia appear to be becoming closer allies in the military industrial arena. Recently Brazil and Saudi Arabia signed a military-industrial agreement. The Saudi Aviation and Defense Minister, Prince Sultan ibn Abdul Aziz and brother of King Faisal, was in Brazil to formalize the agreement. According to diplomatic sources, the Saudi's are particularly interested in the Astro II multiple rocket launcher developed jointly by Brazil and Iraq, as well as the Tucano military trainer now being used by the British Royal Air Force. The Prince spent time at both factories and the Aerospace Technology Center (CTA) in Sao Jose dos Campos (100:7). This could represent a major partnership with the Brazilians providing arms to Saudi Arabia and the Saudis providing Brazil with their much needed oil and foreign exchange.

This view was expressed by Brazilian Air Force General Waldir de Vasconcelos, head of the joint chiefs of staff who said, "We are ideal partners" (100:7). In the ceremonies after the signing of the agreement the Prince

stressed the importance of industrial development in creating new jobs, a statement that was interpreted by some observers to mean that the Saudi's are considering the idea of building their own weapons with Brazilian technology. This interpretation of the agreement was given extra weight when Brazilian Air Minister Delio Jardim de Mattos was quoted as saying "It's all the same whether we build here or there" (100:7). This would also tend to reinforce speculation that the Saudis are the financial backers of the new Tucano plant being built in Egypt. In any case it could be the start of a long and fruitful relationship for both countries.

There were reports that the documents were initially signed on 12 January 1986. Initially this was denied since the Brazilians have a tradition of discretion in their arms deals and leave it up to the customer whether or not to announce an agreement. The agreement reportedly involves sales of US \$1.3 billion during the first 3 years and the addition of the industrial cooperation programs bring the total value of the agreement to US \$3 billion (30). In addition to this agreement Egypt wants to broaden its contract with the Brazilian Aircraft Corporation for Embraer's Tucano training planes (1:16), further tying the commercial future of this partnership together.

The first military equipment shipped from Brazil to

Saudi Arabia under this agreement was the Astros II multiple rocket launcher and the T-27 Tucano trainer (85:48). Also the Saudis are reportedly becoming more directly involved with Brazilian armament development. One report says that Saudi Arabia provided part of the \$54 million needed by Brazil to develop the new Brazilian heavy tank (30). If true, this type of arrangement could provide the Brazilian arms industry with a new source of capital for further growth. But Embraer and Brazil are also looking to other markets for future action.

The Brazilian Aircraft Corporation (Embraer) was at the China Aerospace Fair when it was held at Shanghai in March 1986. Embraer displayed its military aircraft the fast selling Tucano aircraft, and the new AMX fighter plan. Additionally, Embraer brought along its commercial model aircraft. China has expressed an interest in replacing its aging fleet of aircraft and Embraer intends to take advantage of such a huge opportunity (1:17). The size of this opportunity was apparent recently when the new Chinese military attache in Brasilia indicated that the purchase could include 500 Embraer AMX tactical fighters and 2,000 Tucano trainers (28:MO9). With the attempt to capture both Middle Eastern markets and the Chinese markets along with consolidation of the Latin American market, Embraer is mapping out a strong position which would assure

long-term corporate growth and survival.

The U.S. Ambassador to Brazil, Diego Asencio, has seen the potential rise of Embraer in the world markets. He has reportedly been to the Pentagon to argue that buying the Tucano to replace the failed Fairchild T-46 trainer could soften Brazilian resistance to U.S. arms trade restrictions. This would open the way for a U.S. contractor to work with Embraer on the supersonic fighter (90:6). Embraer is very interested in a large sale of Tucanos to the USAF. "The company recently bid on a highly competitive \$1.3 billion deal with the U.S. Air Force to supply 500 military trainers" (94). The bid has not been rejected and the USAF sent five officers to the Embraer facility in Sao Jose dos Campos to examine the facilities. Their visit was concluded on 19 October 1985 (96:9). The results of these actions have not yet been announced. The outcome of this possible commercial deal could have a significant impact on military industrial cooperation between the U.S. and Brazil for some time into the future.

Brazil's aggressiveness in aircraft sales coupled with its standing policy of not requiring end use certificates from its clients indicates an intention of market expansion (41:11). How this strategy continues in the light of future international relations with the U.S. is examined next.

#### 4.8 Brazil-U.S. Relations

The relationship between Brazil and the U.S. is currently improving following a decline in cooperation and association that lasted from the mid 1950's to 1977. The relationship is currently improving but most likely will not reach the same accommodation levels of prior to 1955 due to Brazil's growing strength and foreign policy independence.

There would be many policies for Brazil and the United States to negotiate before a successful joint supersonic fighter project could start even though the basic guidelines already exist {see Appendix D}. All of these would have to take place in the context of Brazilian and United States relations which have not been consistent in recent years. The following is a brief look at these bilateral relations in this century.

4.8.1 Relations Prior To 1977. From WW I Brazil enjoyed close naval ties with the United States and hosted a U.S. Naval Mission. This relationship was reinforced with the Brazilian Navy receiving arms as part of the compensation for a United States missile tracking facility on Brazil's Fernando de Noronha Island (86:27,28). Brazil also fought alongside the United States in WW II in Italy {see Section 3.1.5}. However this close and cooperative relationship was not to last.

In the 1950's U.S. President Eisenhower stopped federal developmental loans to Brazil and insisted on private investment. This action caused the Brazilian government to adopt a nationalistic development program and started the separation movement away from the U.S.

(ADI:31). As Brazil received declining support from the United States, its attitude and the relationship between the two countries started a decline.

The United States started to neglect the treatment of Brazil as a close wartime ally and grouped it into an area of 'Latin American' countries when considering actions toward Brazil. This became evident in the mid 1950's. When Brazil wanted an aircraft carrier to help protect its vital shipping lanes in the South Atlantic, Brazil first approached its ally, the U.S., and sought to purchase one. The United States refused to sell Brazil an aircraft carrier on the pretext of preventing the spread of 'modern arms' into Latin America. Brazil made its independence felt by purchasing an aircraft carrier from Great Britain in December 1956 and had it refurbished in a Dutch shipyard (86:28). Although it cost Brazil a great deal of money it did reinforce their independence and provide them with the arms they desired. This incident became a precursor for other actions in the future. In short, Brazil's loyalty as a staunch ally, being the only Latin American country to

fight with the United States in both World Wars, failed to gain it any special treatment in its quest for modern military equipment in either the fifties or sixties (11:74). This did not help the relationship.

The bilateral relationship met even further difficulties during the years from 1968 to 1972. During these years Brazil's security forces were fighting urban guerrillas and terrorists composed of extreme leftist and communist groups. At this time the U.S. Congress was more concerned with South East Asia and individual human rights in Brazil than with the political relationship. With the U.S. Congress blocking military assistance requests and arms sales Brazil turned to Europe for equipment to modernize its armed forces.

The Europeans were much more accommodating in Brazil's quest for military equipment. In May 1970, Brazil purchased sixteen French Mirage III aircraft and broke the U.S. imposed 'jet ban' in South America (11:74). This occurred after the U.S. refused the Brazilians F-5 fighter aircraft (86:28). Later in 1970, the Brazilian Navy ordered six Vosper Thorneycroft frigates armed with sophisticated antiair, antisubmarine, and antiship missiles from Great Britain. "This \$280 million warship purchase provided for four vessels to be built abroad, and the remaining two to be co-produced under license in the naval shipyard in Rio

de Janeiro" (11:74). Also, the Brazilians later bought six West German coastal minesweepers and three British Oberon-class submarines (11:74). All totalled in the period from 1968 to 1972 "the Brazilians bought nearly \$500 million in military equipment from European suppliers and received only \$76 million in military aid from the United States" (86:28). Brazil was now set toward an independent foreign policy because of U.S. unwillingness to help modernize a close long-time ally. Brazil has been adopting a highly independent foreign policy and defending its own interests rather than those of the United States since that time (8:79).

The Nixon administration sensed this weakening of Brazilian and United States relations and tried to help correct the situation by stepping in to ensure a sale of Northrop F-5E's to Brazil in 1973 (11:75). As with many after the fact actions this was a case of too little too late.

Relations were to deteriorate further under the Carter administration. The United States confirmed {in the Brazilian view} that the U.S. was interested in keeping the "junior allies" in line and prevent them from improving their standing in the international order (8:78). The final break came when President Carter ordered an investigation of human rights policies in all countries receiving U.S.

military aid. The Brazilians were outraged by this attempted interference in their internal affairs. Brazil cancelled all bilateral military and diplomatic agreements with the United States and renounced the \$77 million in annual U.S. aid (23). The relationship between the United States and Brazil had hit bottom.

4.8.2 Relations From 1977 to the Present. The improvement in United States and South American relations had its first real demonstration when the U.S. transferred F-16 aircraft to Venezuela at the beginning of the 1980's. This reversed, for the first time, a U.S. policy of refusing to sell state-of-the-art aircraft in Latin America (27:46). Negotiations to improve relations with Brazil were not far behind and they started in 1982 {see Appendix D}.

On February 6, 1984 the Reagan administration announced an agreement that reestablished the military relationship with Brazil that was suspended seven years ago during the Carter administration (80). This new series of agreements covers economic and scientific cooperation in which the U.S. agrees to provide Brazil with new arms technology for its industry. Under these agreements the United States reserves the right to approve all sales of Brazilian arms which contain any U.S. technology (23:6). This did not promise to increase military trade between the two countries because the U.S. right to veto the sale of a

Brazilian made weapon containing U.S. technology is exactly the kind of condition Brazilians strenuously avoid with foreign suppliers (41:11). Because Brazil's is an export driven industry this type of agreement may only be slightly better than no agreement at all.

The sense of friction inherited from earlier administration's policies makes Brazilian firms hesitate before entering into deals with U.S. firms. The Brazilians do not want to be hindered by an arbitrary U.S. presidential policy in the future (2:2). To help alleviate these concerns U.S. Undersecretary of Defense for Policy, Fred Ikle, spent 3 days in Brazil meeting with military leaders in Brasilia. He then visited the country's three major arms factories in Sao Paulo, including Embraer (74:11). Two months later USAF Secretary Edward Aldridge went to Sao Paulo where he flew in the Tucano. This May 1986 trip was seen as part of a growing U.S. effort to restore U.S. relations with the Brazilian arms industry and military (63:10). Reportedly the U.S. government has offered backing for major U.S. defense contractors to start joint ventures in Brazil. The major condition is that the Brazilians agree not to transfer sensitive technology to countries hostile to the United States (whether the condition was all technology or 'sensitive' technology is not clear, however the governmental MOU states all

technology}. The Brazilians have refused to use technology requiring U.S. approval for transfer, supposedly, thwarting a major goal of a 1984 visit to Brasilia of the U.S. Secretary of State George Schultz (41:11). This Brazilian independence is apparent in equipment purchases as well.

The following comment was made about a competition for Brazilian purchase of military helicopters:

"Sikorsky very effectively addressed Brazilian military needs but was the probable victim of a backlog of U.S. conditions- about arms sales, nuclear power and human rights- that drives Brazilians into the arms of partners who do business with fewer policy restraints. If there is no change in the U.S./Brazil relationship Marcel Dassault and British Aerospace have a much greater chance of building the Brazilian supersonic fighter than would a U.S. firm" (41:11).

This is illustrative of the great importance the bilateral political relationship has on the military-industrial relationship.

4.8.3 Brazil and the U.S. Today. Today the Brazilian government is following a foreign policy independent of the superpowers and is encouraging other Third World countries to do the same. In discussions with other South American and African countries the Brazilian government has advocated keeping the superpower confrontation out of the South Atlantic region. The Brazilian government avoids military pacts with European countries, the United States, and South Africa, as well as African nations on the South

Atlantic coast. This gives Brazil the independence from other countries that it seeks. The Brazilians also believe that it is necessary to keep both the Soviets and the Americans from installing permanent naval bases on South Atlantic coasts to help avoid conflict in the region (11:76). This is very important to Brazil because approximately 98 percent of Brazilian commerce is carried by ship in the South Atlantic (11:77).

The Brazilian independence is also felt in other areas, for example, Brazil has refused to embargo grain from the U.S.S.R. at the request of the U.S. government. Brazil has also refused to join a South Atlantic Security Pact which is a military agreement the U.S. desires. Brazil also voices its disagreement with the United States assessments of the situations in El Salvador and South Africa (86:31). This indicates that although Brazil is a western capitalist country it is an independent power with independent policies in the world today.

The Brazilians consider arms export policies as an extension of long-term objectives for Brazil. The continuation of the arms supply can be considered as a long-term investment in making the country a reliable international partner. This is an especially important move in the case of a country that only recently became active in the international arena (8:80). While the U.S.

engages in arms sales and transfers for primarily political reasons, Brazilian armament exports are generally economically motivated (11:87). As we saw in Section 4.4 the reasons for this cannot be changed in the near future. Therefore the U.S. can not expect Brazilian policies to change.

The Brazilians will limit arms sales in special cases but these are rare. In August 1985 President Sarney signed a decree imposing sanctions on South Africa. Among the sanctions it prohibits selling arms to South Africa or Namibia (73). This brings the total number of countries Brazil will not sell to, to three: South Africa, Cuba, Iran (82), even though there is speculation that arms which Brazil sells to Libya are then transferred to Iran with Libya taking advantage of the no end use certification policy of Brazil.

The United States would like to see the Brazilian ban on arms sales extended to Libya. Some think that the reason for the United States' 1984 Memorandum of Understanding on military cooperation is to limit arms sales to Libya (93). However the Brazilians will most likely continue to sell arms and may even expand business with Libya. The Libyan ambassador to Brazil says Libya wants to raise trade to \$1 billion per year. Brazil is now third in arms sales to Libya with the U.S.S.R. first, and the European Economic

Community (EEC) second (24). Even though the United States may not like some of Brazil's independent actions there is reason to encourage Brazilian activity in the international arena.

The early experiences of most developing nations makes them suspicious of the motives of the superpowers and former colonial powers, Britain and France, in dealing in arms (4:26,27). The Brazilian motives are not questioned in this manner. Even though Brazilian arms sales may decrease U.S. influence in an area or country, there is no increase in Soviet influence. Additionally Brazil has the capacity to potentially cut into Soviet markets too (4:24), which would help turn more countries toward a western capitalist country, Brazil, and away from the U.S.S.R.

The Latin American nations have wanted a relationship with the United States as equals (4:2). But past U.S. actions have not allowed this to take place. Latin American countries have come to view U.S. involvement south of its border as imperialist in most respects. During this same time period Brazil has been experiencing increasing acceptance by its neighbors. Brazil may now be in a position to provide a stabilizing influence in economics and politics which the U.S. can not because of Latin American suspicions about the United States' motives. If the U.S. were to provide support for Brazilian policies in

the region this influence for achieving stability may be assured (11:21). If Brazil were to emerge as a leader of the Third World and a strong regional power, the strategic interests of the U.S. may also be helped (4:2). More countries might reject the communist view of government and economics and adopt the Brazilian road to economic growth.

#### 4.9 Summary

The prospects for a joint U.S. and Brazilian supersonic fighter project are lukewarm. Even though the basic agreements for formation of a joint project already exist there are factors both for and against it {see Table 2}. The factors which favor the U.S. and Brazil working together are the technical and industrial characteristics of both the the Brazilian and U.S. aircraft manufacturers. The other areas have reasons both for and against the cooperation of the United States and Brazil on a supersonic fighter project. The major issue is technology export control, which the U.S. now insists on. This issue is behind unfavorable factors in business concerns (Section 4.5), Brazil and U.S. relations (Section 4.8), and may be a contributing cause in current activities (Section 4.6) and Brazil's focus of future actions (Section 4.7). When all factors are weighed, it appears that if the technology control issue can be worked out to the satisfaction of both

Brazil and the United States then a partnership for development of a Brazilian supersonic fighter could be favorable for both countries. If a Brazilian supersonic fighter were to be built then, the question of organizational form for the venture must also be addressed.

TABLE 2.

## Summary Table For Factors

FACTOR	FAVORS PROJECT	NEUTRAL	DISFAVORS
1. Design factors	Embraer has most technical skills needed. U.S. firms could provide the added skills necessary for project.		
2. Production factors	Embraer has the basic skills and training needed for this project and is willing to expand capacity as necessary.	Brazil does not have the capacity and cannot transfer factory facilities from other areas.	
3. Aircraft operations requirements	The operations requirements are within the abilities of many U.S. companies.	The operations requirements are much less than USAF requirements & aircraft most likely would not be used by the USAF.	
4. Business concerns	The large financial investment required & great deal of technical work favor a large partner similar to several U.S. contractors.	The requirement for U.S. approval in all exports can not be accepted by Brazil in an export driven industry since all customers are not on favorable terms with the U.S.	
5. Current activities	Embraer currently has two multinational military aircraft projects giving Embraer experience in this area.	There are no joint U.S./Brazil military projects at the present time.	
6. Future actions	Embraer is consolidating its relationship with mid-eastern customers and attempting to open relations with China. Both of these thrusts may be of a higher priority to Brazil than bettering relations with the U.S.		
7. Brazil/U.S. relations	Brazil & U.S. relations are friendly and improving after a period of declining relations. The prospects for this project in this area are better than at any time since the early 50's.	Brazilian political independence and foreign policy can not allow for the U.S. or any other country to control Brazilian arms exports.	

## **5. Brazilian Supersonic Fighter Development Alternatives**

In the formation of any large project, such as a supersonic fighter, the organizational design must be chosen carefully. The most desired organizational design is one that minimizes risks and maximizes the attainment of goals. This chapter examines Brazilian aircraft industry goals, evaluates three organizational alternatives, and concludes with comments on the organizational design which appears to be best suited for the development of a Brazilian supersonic fighter.

### **5.1 Brazil's Long Term Aircraft Industry Goals**

The Brazilian government supports an indigenous aircraft industry for three reasons. It strives to achieve an independent national defense capacity, upgrade Brazil's independent technological capabilities and improve Brazil's balance of payments (64:34). Brazil is trying to meet this objective while avoiding some of the problems encountered by other newly industrializing nations.

Many nations have problems trying to absorb new technology when that technology comes from somewhere else. They may become dependent on nationals from other countries to maintain and operate weapons systems or they may need to send large numbers of nationals to other countries for training. The former results in the technology never being

fully acquired and the latter may result in social problems for the developing country. Some of the more typical social problems experienced include people leaving the industrializing country or the adoption of social habits foreign to the native culture. In either case, both of these approaches have often become expensive short-term solutions which leave the industrializing country in a subservient role to the country providing the technology (55:44). Brazil has sought to avoid both of these problems in acquiring new technology to help further its aircraft industry goals.

### 5.2 Licensing

When Embraer Aircraft Corporation was questioned about the prospects of licensing, its attitude was expressed in the following statement: "Embraer designed the Tucano trainer and participated with the Italians in the design of the AMX. Thus Embraer's emphasis has been on the development of its own aircraft programs and not on licensing the designs of others (64:36)." Embraer has a strong corporate bias against licensing an aircraft design.

To examine the reasons that Embraer does not like the idea of licensing a U.S. design such as the F-16 or F-20, the extent of the effort, advantages and disadvantages of

licensing for Brazil must be considered.

Licensing greatly reduces the amount of effort required to manufacture an aircraft. Because the design is already built and tested, the development cycle is effectively eliminated. Manufacturing set up costs would still be incurred for Embraer because of its current lack of industrial capacity for this project {as described in Section 4.3}.

This great reduction in scope would represent a substantial reduction in investment required from the \$1 billion estimated for a joint project. Since the facilities and additional personnel would still have to be trained the fixed costs for a project of licensed fighter production could be expected to be only cost 25 percent of a development program {author's estimate}. With the price of the fighters limited to the range of \$10 to \$15 million from Section 4.5.2 an initial estimate for the production run breakeven point can be made.

Using basic economics the breakeven point for a product is reached when total costs equals total revenue. This means the breakeven point can be estimated with this equation:

$$X = F / ( P * CM )$$

The equation comes from:

$$P * X = \{(1 - CM) * P * X\} + F$$

where

X = breakeven numbers of fighters

P = price of a fighter

CM = contribution margin

F = fixed costs

note:  $\{(1 - CM) * P * X\}$  equals variable costs  
The CM represents the amount of a fighter's price  
which goes to paying off the fixed costs up to the  
breakeven point. After the breakeven point has been  
reached the CM becomes the profit margin on each  
additional aircraft sold.

Using these equations and the public estimates of costs of a supersonic fighter project the cost versus revenue curves can be plotted as shown in Appendix E, Figure 12. As shown from these curves and equations the breakeven point for the number of fighters in a license agreement ranges from 67 to 250 for our example case {see Table 3}. From the cost curves it is apparent that the breakeven point is more sensitive to the CM than to the price. For ease in comparing alternatives the breakeven number of aircraft versus the contribution margin was plotted {also shown in Appendix E, Figure 15}. This curve shows that Embraer cannot be expected to reach the breakeven point under any reasonable circumstances with less than 50 aircraft. After examining the basic economic factors other advantages and disadvantages must be considered.

TABLE 3  
Breakeven Points for Licensing

Price per Aircraft	Contribution Margin	Number of aircraft to breakeven
\$ 15 million	.25	67
\$ 15 million	.10	168
\$ 10 million	.25	100
\$ 10 million	.10	250

5.2.1 Advantages. There are basically two advantages of licensing a fighter design. First, there is very little risk. Because the fighter has been designed and built previously there is very little risk compared to designing a new aircraft from the beginning. The project has already been accomplished and the licensee need only assemble a manufacturing assembly line which has been previously developed elsewhere. Second, the costs of a licensed fighter project are substantially reduced because of the reduced effort necessary.

5.2.2 Disadvantages. The disadvantages of licensing are several although not as obvious as the advantages. First is the problem of limited growth potential in terms of market and product line (32:6). Typically the licensee of a product is limited to its own domestic market, with the licensor reserving the right to international sales. The return to the licensor is also typically granted as a percentage of the sales price of an aircraft. This helps

decrease the contribution margin a licensee is able to achieve since it is a direct fixed percentage of price. This means that it would be even more difficult for Embraer to achieve a .25 CM with a \$15 million price so the breakeven number of aircraft would most likely be 67 in the best case. From the plot of CM versus breakeven number, Appendix E Figure 15, it can be seen that in no reasonable case could the breakeven number fall below 50. This may not appear to be important except that the entire Brazilian Air Force currently only has 47 air-to-air fighter aircraft (28:FS4); therefore, on any licensed project Embraer would lose money, even if Brazil replaced its entire air-to-air fighter force.

Second, a licensed fighter aircraft project would result in Brazil remaining dependent on another country in its defensive capacity. This goes against Brazil's long-term goals of a better position in world politics and consolidation of Brazil's preeminence in South America. It also hinders Brazil's shorter term goal of an independent national defense capacity.

Third, as a licensee of an aircraft design, Embraer would not be able to significantly add to its domestic technological base. Brazil has been aggressive in trying to increase its technical base for economic reasons as well as political ones.

Fourth, a license agreement for the production of a fighter restricts Brazil from earning foreign exchange. Because of Brazil's great external debt, the addition of debt incurred from buying a fighter license, and a restriction on earning any foreign exchange to help pay this debt, a license agreement would be most distasteful to Brazil.

5.2.3 Practical Problems. The most obvious practical problem, above and beyond the pros and cons of a license agreement, is: who could a fighter design be licensed from? Currently there are two designs on the market which may meet the Brazilians' requirements: the F-20 and F-16. Northrop refused to license Embraer its older F-5 design as previously discussed, and is currently set on a policy of export distribution for its F-20. That leaves only General Dynamics. General Dynamics has been assembling F-16's in many customers' countries so this may be possible; however, due to Brazilian goals and the economics of this venture, this does not appear to be practical unless an extraordinary arrangement can be made {see Section 6.5.2}.

### 5.3 Joint Venture

Embraer has extensive experience in international joint venture projects. Embraer has worked with several companies on complete aircraft and with numerous

suppliers. The joint venture organization may hold great promise for Embraer in its development of a supersonic fighter aircraft.

In a joint venture the amount of effort that a company has to expend is greater than that required by a license. Usually all stages of the development cycle must be carried out, because this type of venture would be a complete development program using more than one organization.

As previously discussed the amount of investment required for this level of effort is approximately \$1 billion. By using the same methods for economic estimation as previously discussed, the breakeven number of aircraft required to be produced for Embraer rises to between 267 and 400 for optimistic estimates {see Table 4, and Appendix E, Figure 13}.

TABLE 4  
Breakeven Points for a Joint Venture

Price per Aircraft	Contribution Margin	Number of aircraft to breakeven
\$ 15 million	.25	267
\$ 15 million	.10	667
\$ 10 million	.25	400
\$ 10 million	.10	1,000

It could be as high as 1000 if Embraer could only receive a price of \$10 million per aircraft with a .1 contribution margin. By examining the breakeven number versus the

contribution margin, also in Appendix E, a joint venture becomes economically viable for Embraer if it can sell a minimum of between 300 and 400 aircraft.

5.3.1 Advantages. The advantages of a joint venture project are almost the mirror image of the disadvantages of licensing. First, Embraer may be able to make money with this type of arrangement. With a joint venture agreement, Embraer would be able to export its aircraft to other countries. This increases the potential market for an aircraft considerably. If Embraer could sell the supersonic fighter with a success rate near that of the Tucano trainer, it could very easily reach the breakeven point of sales and have the supersonic fighter project produce a profit for Embraer and Brazil.

Second, the export sales of a supersonic fighter would help Brazil in its need to earn foreign exchange. This would help reduce the Brazilian foreign debt and improve the country's economic position.

Third, a joint venture structure would help the Brazilians increase their technology base. This type of arrangement could improve the areas where Embraer's design and production capacity are not as strong as the company wishes {see Sections 4.2 and 4.3}. This would also allow the joint venture partner to take advantage of Embraer's strengths in marketing, sales and low labor costs. The

expansion of Embraer's technical base could be beneficial to both the company and Brazil for many years to come.

Fourth, a joint venture would allow Brazil to gain a defense capacity with greatly reduced dependence on other countries. This would help Brazil achieve these long-term goals: a better position in world politics, consolidating Brazilian preeminence in South America, the establishment of air power, and improving the Brazilian war industry. This represents a significant amount of benefits from one industrial program and should be very attractive to the Brazilians.

Fifth, the prospects of a joint venture in a fighter aircraft development project would have significantly less risk and be less of a financial burden than if Embraer were to attempt the supersonic fighter project alone.

**5.3.2 Disadvantages.** The disadvantages of a joint venture also mirror the advantages of a license project. The investment required for a joint project is much greater than that required for a licensed program. However, when compared with the economic realities of the marketplace this cost is outweighed by the market access. Secondly, the risk of developing a new fighter is much greater. There is not much that can be done to alleviate this except for using proven technology and prudent management. In many areas of arms the Brazilians have proven adept at

both.

5.3.3 Practical Problems. The biggest practical problem is finding a suitable partner for a joint venture. Since this was covered in section 4.5.2 it will not be repeated here except to state that there seems to be many potential partners for this type of project.

#### 5.4 Internal Development

The third alternative is for the Brazilians to develop the supersonic fighter program on their own without help from another country. This could be done if Brazil were able to acquire all the necessary facilities and educate all the necessary engineers in both domestic and foreign universities.

This development approach would entail a great deal more effort than a joint venture project. Since it takes both time and money to train and educate people and to buy equipment, the initial investment required by the Brazilians would increase tremendously. Considering that it takes four to six years to train an engineer and more than one or two years to acquire all the equipment that Brazil would need, the costs would increase significantly. If the costs of investment over six years before full development efforts were to be included, then the initial fixed costs would be at least twice that of a joint

program. With a development cost of US \$2 billion for this type of program, the breakeven points for the number of aircraft to be sold rise dramatically as shown in Table 5. The breakeven number versus the contribution margin chart in Appendix E, Figure 15, shows that the contribution margin must be at least 26 percent to achieve a breakeven point of 500 aircraft.

TABLE 5

Breakeven Points for an Internal Development

Price per Aircraft	Contribution Margin	Number of aircraft to breakeven
\$ 15 million	.25	534
\$ 15 million	.10	1,333
\$ 10 million	.25	800
\$ 10 million	.10	2,000

5.4.1 Advantages. The advantages of this type of capacity development are basically the same as those for a joint venture arrangement. First, Embraer would be able to export its aircraft to other countries. This increases the potential market for an aircraft considerably. However, because of the high initial investment the prospects of reaching the high breakeven numbers would entail a large amount of market risk.

Second, the export sales of a supersonic fighter would help Brazil in its need to earn foreign exchange. This would help reduce the Brazilian foreign debt and improve

the country's economic position if the sales became profitable.

Third, internal development would be the most comprehensive route for the Brazilians to increase their technological base. This type of arrangement could improve Embraer's design and production capacity in areas of the company's choice {see Section 4.2.1}. This approach to expansion of Embraer's technical base would entail a great deal of risk in using new trainees without much experience to improve capabilities.

Fourth, internal development would assist Brazil in acquiring a defense industrial capacity with virtually no dependence on other countries. This would also help Brazil achieve its long-term goals in the same way as a joint venture.

5.4.2 Disadvantages. The disadvantages of an internal development program are threefold. The first, and most immediate, is the high initial cost. This \$2 billion cost is approximately twice that of the entire Brazilian military budget of 1984, and is roughly 10 percent of the entire Brazilian government budget of 1983 (28:1). So the ability of Brazil to finance an internal development is questionable. Additionally, the high cost also introduces considerable market risk. The high initial cost drives the number of aircraft needed to be sold to breakeven and

produce a profit substantially higher and it may be questionable if such a large market even exists.

Second, this option presents the highest technical risk. Since a large portion of the people involved in this type of project would be newly trained the level of experience would be low. Usually this leads to more numerous redesigns and initial mistakes which could make the internal development program even more costly.

Third, the development time would be increased by about six years. The AMX project is taking eleven years from the start of feasibility studies to the first production aircraft delivery (33:20). If the time for a supersonic fighter project was nearly the same, and the additional six years were added, then the total development time for an internal development fighter project could be 17 years. If this were to occur, the costs to be recovered from development, tooling and education could drive the initial cost well over US \$2 billion. This type of development cost could make the entire program economically unfeasible for both Embraer and the Brazilian government.

5.4.3 Practical Problems. The main practical problem is investment costs. How much could Brazil and Embraer invest in this type of project and how much would they be willing to invest? This is suggested as a topic for further research in Section 6.5.4. The amount may not be

enough to cover an expensive, high risk internal supersonic fighter program.

Time is the other practical problem. The targeted market for a Brazilian supersonic fighter stems from a desire to replace the aging F-5 and Mirage III fighter aircraft. This is much the same marketing tactic that Embraer used in targeting its Tucano to replace the aging Cessna T-37 aircraft. The Mirage III's were purchased in 1970 and the F-5's were delivered in 1976 (28:4). Because many other countries also purchased these aircraft in the same time frame this market niche may be expected to open up in the mid to late 1990's when those aircraft reach an age of 20-25 years, which is usually the designed end of economic life for military aircraft. If the internal development route were to stretch this time out, the aircraft would not be ready for production until after the year 2000. In this case Embraer may miss the opportunity and induce an overwhelming market risk.

### 5.5 Summary

In this section three possible approaches for a Brazilian supersonic fighter program were examined {see Table 6}. The prospects for licensing were examined first, and found to be impractical and undesirable from both a basic economic viewpoint and the satisfaction of Brazilian

goals. Next, the prospects for a Brazilian joint venture were examined and found to be very desirable. An initial appraisal of the economic considerations shows that this type of organization has good prospects in light of the potential market. The other national goals of Brazil are also able to be met by using this type of arrangement. Finally, the possibility of an internal development approach was briefly considered. Internal development was found to be a very expensive approach, with the highest risk of the three organizational approaches. Based on this examination, it is expected that Embraer will pursue a joint venture approach exclusive to all other options. If the U.S. aerospace industry is to participate in a supersonic fighter project with Brazil it must be ready to form a Joint Venture with Embraer, and not attempt to export aircraft to the Brazilians to meet their supersonic aircraft needs.

TABLE 6  
Summary Table for Organization

APPROACH	ADVANTAGES	DISADVANTAGES
Licensing	<ul style="list-style-type: none"> <li>-Low initial fixed costs</li> <li>-Low development risk</li> </ul>	<ul style="list-style-type: none"> <li>-Embraer would lose money</li> <li>-Brazil would not have an independent defense capacity</li> <li>-Technology base would not expand as necessary for Brazil</li> <li>-Brazil would not be able to earn foreign exchange</li> </ul>
Joint Venture	<ul style="list-style-type: none"> <li>-Embraer has a good prospect to make money on program</li> <li>-Raise foreign exchange earnings and decrease Brazilian debt</li> <li>-Increase Embraer and Brazil's technical base</li> <li>-Improve Brazil's independent defense capacity</li> <li>-Less risk than internal development</li> <li>-Less cost than internal development</li> </ul>	<ul style="list-style-type: none"> <li>-Costs increase over licensing</li> <li>-Risks increase over licensing</li> </ul>
Internal Development	<ul style="list-style-type: none"> <li>-Export opportunity</li> <li>-Raise foreign exchange if successful</li> <li>-Increase technical base of Embraer and Brazil</li> <li>-Long schedule time</li> <li>-Improve military industrial capacity</li> </ul>	<ul style="list-style-type: none"> <li>-VERY high initial costs</li> <li>-High market risks</li> <li>-High technical risk</li> <li>-Ability of Embraer and Brazil to support program questionable</li> </ul>

## **6. CONCLUSIONS**

This chapter provides an overall summary of the prospects for a joint United States and Brazil supersonic fighter project. The findings and discussion results are reviewed briefly, then the thesis question is restated with the answer from the research. Next the significance of this finding and the implications for the future are examined. Finally, recommendations for further research are provided.

### **6.1 Summary of Findings and Alternatives**

During the investigation of this subject area several important facts surfaced. First, Embraer is a technically capable company which could cooperate with U.S. manufacturers in a supersonic military fighter aircraft project. The company of Embraer is also aggressively pursuing expansion of its product line, markets, technical expertise and production capacity. This is necessary because of the small domestic market for aircraft compared to the number of aircraft which are needed to be produced for Embraer to remain a financially healthy organization. Second, as a result of the first factor, Embraer is very sensitive to possible restrictions on its export products. Brazil is also politically sensitive to the possibilities of other countries interfering with its commerce. Another

factor that surfaced is that the flight operations requirements for a Brazilian fighter are less than those of the USAF even though the logistics desires are similar. These all contribute to the current situation: today there are no joint military aircraft development projects between the U.S. and Brazil.

Embraer is actively expanding its aircraft sales and service operations worldwide. It is now engaged in a joint military attack aircraft program with two Italian companies in the AMX project. Embraer is also expanding the production facilities for its Tucano trainer by setting up factories in both Ireland and Egypt in addition to the main factory in Brazil. These facilities provide both industrial offset and aircraft for Embraer's international customers of Egypt and the United Kingdom. In addition to these activities Embraer is also consolidating its relationships with Mideastern and Latin American customers while attempting to break into the Chinese market. With these activities Embraer and Brazil may find their international expansion and political independence much more rewarding than accepting U.S. control over its armament exports.

In examining three possibilities for supersonic fighter aircraft development, the joint venture option was a clear winner. The prospect of licensing did not provide Brazil with an independent defense capacity or the

opportunity for technical growth, or the ability to earn export exchange. Additionally the basic economic prospects for the program indicate that Embraer may suffer an economic loss under this type of arrangement. The prospects for a joint venture are much better. This type of structure allows for Embraer to expand its technical base and export aircraft to earn a profit. Additionally Brazil would gain the military industrial independence it seeks. If Brazil were to attempt to develop and produce a supersonic fighter using only its own resources by internally developing the skills and equipment required, it would realize the same basic benefits as a joint program. The problem is that this approach is prohibitively expensive and introduces additional risks that make this organizational option imprudent. Embraer has demonstrated in the past that it is smart, aggressive and opportunistic, but most emphatically not imprudent. Therefore the joint venture arrangement with a willing partner is the organization structure of choice for a Brazilian supersonic fighter program.

#### 6.2 Thesis Question and Answer

**Question:** Would Brazil and the United States be suitable partners for a joint supersonic fighter aircraft development and production project?

**Answer:** No. If the issues of export policy restrictions and U.S. approval of individual cases for export of equipment using U.S. technology can be worked out to the satisfaction of both countries then the answer would be, yes {see sections 6.5.1 & 6.5.2}. At the present time there are no technical or industrial reasons why the two countries could not work together on a supersonic fighter aircraft project.

### **6.3 Significance**

This thesis has studied the primary aircraft manufacturer of Brazil. Brazil is the single most powerful nation in the southern hemisphere and the second most powerful nation in the western hemisphere. Brazil has shown tremendous economic and industrial growth in the recent past and its aircraft manufacturer, Embraer, has been a part of that growth. This company has grown rapidly and is starting to examine the feasibility of producing supersonic military fighter aircraft. If the United States is willing to make some concessions in areas vital to Brazilian aircraft marketing and sales goals, then the U.S. may also be a part of Embraer's continuing growth. If not, then supersonic weaponry may be produced outside of the United States, U.S.S.R. or Europe for the first time. If this happens it may be the start of a military power

realignment in the world with unknown effects on our future.

#### 6.4 Implications for the Future

Embraer sees the United States as abandoning the manufacture and use of "exportable" fighter aircraft in the future as the U.S. moves into using 'stealth' technology with development of programs such as the ATF. Since the vast majority of countries do not see the U.S.S.R. or the U.S. as their primary potential adversaries, older technology equipment will remain suitable for most areas of the world. As the military fighter aircraft of the late 1960's and early 1970's reach the end of their economic life the U.S. does not appear to have a new aircraft which would be acceptable to these customers at a lower price than the F-16. As Embraer fills this developing market void the prospects for Embraer's future could be very bright. It is entirely possible that Embraer will do to the international fighter aircraft industry what Japan did to the U.S. domestic auto industry.

As a side issue, the rise of Embraer may have some positive effects for the United States. The first is a potential direct benefit. If United States aircraft plants were destroyed or sabotaged at some time in the future Embraer and Brazil may be in the position to provide

fighter aircraft for the USAF in a time of emergency. Second, as Brazilian arms exports expand in the lower priced end of the spectrum the western political position may be strengthened. Also, as more countries begin to buy arms from Brazil instead of the U.S.S.R., the Soviet influence could decline in the world. If this happens, the political balance could shift further to the west with a decline of Soviet influence even though the strength of the U.S. may not grow directly.

#### 6.5 Recommendations for Further Study

The following subjects are recommended for further study.

6.5.1 Topic 1. What is the possibility of changing the U.S.-Brazil MOU on military industrial cooperation from U.S. approval for all transfers of technology {see Appendix D, Articles: 1.2.2, 1.4, and 1.4.2} to no transfer of "critical" U.S. technology. When coupled with an appropriate definition of critical and/or a listing of such technologies the new agreement may allow Brazil to acquire supersonic capacity without releasing technology which may hurt the United States.

6.5.2 Topic 2. Investigate the possibility of having the United States purchase the Tucano trainer in a packaged deal with Brazil buying a supersonic fighter {F-16 or F-20}

from the U.S. Even though this would not provide Brazil with a supersonic fighter capacity it would fulfill the two main objectives of Embraer in relation to Brazil. With the proper financial structuring of the deal Brazil could modernize its own fighter force, acquire the skill necessary to produce spares necessary for its own national defense, and earn foreign exchange. The United States would receive the new trainers the USAF needs at a greatly reduced cost {compared to redesigning the failed T-46} and improve relations with a rising power in the world.

. 6.5.3 Topic 3. With the problems Northrop has been having selling the F-20, what are the prospects of Embraer buying all rights to the aircraft or becoming the international distributor for the plane?

6.5.4 Topic 4. What is the total maximum financial load Brazil and Embraer may be able or willing to carry in pursuing a supersonic fighter project?

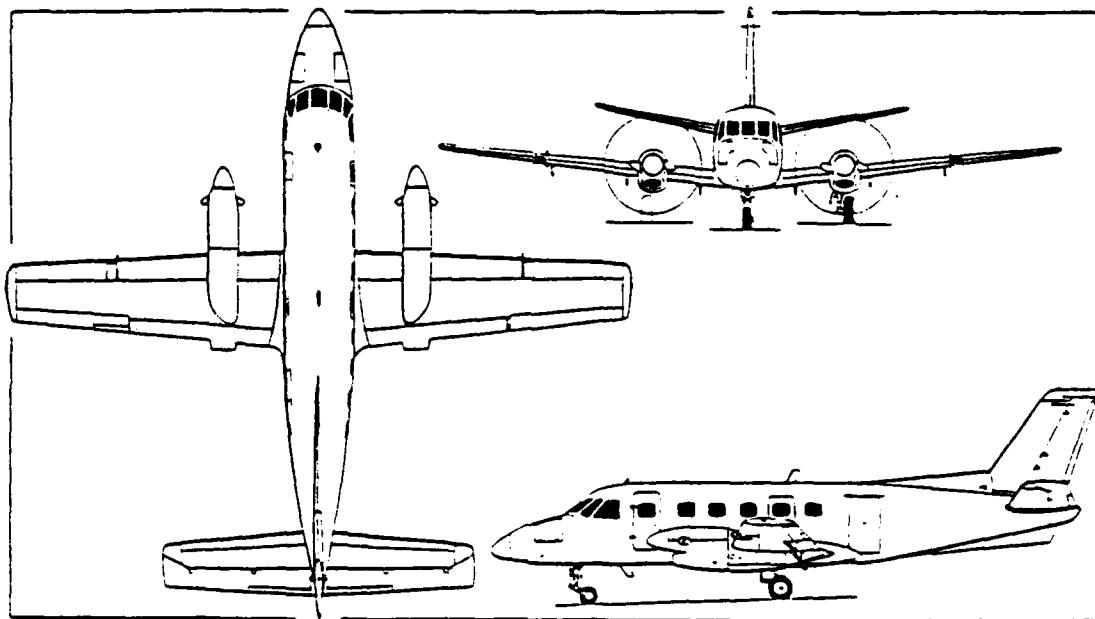
#### 6.6 Summary

This thesis examined the prospects for a joint supersonic fighter aircraft project between the United States and Brazil. There were seven study areas covered: aircraft design factors, aircraft production factors, aircraft operation requirements, business concerns, current activities, possible future actions and Brazilian-U.S.

relations. The results indicated factors both for and against a fighter aircraft development partnership between the United States and Brazil. The main obstacle to such a relationship appears to be the technology export control laws and policies of the two countries. If this issue can be resolved to the satisfaction of both countries, then this could be a mutually profitable joint venture project.

Appendix A: Embraer Aircraft Illustrations

BANDEIRANTE



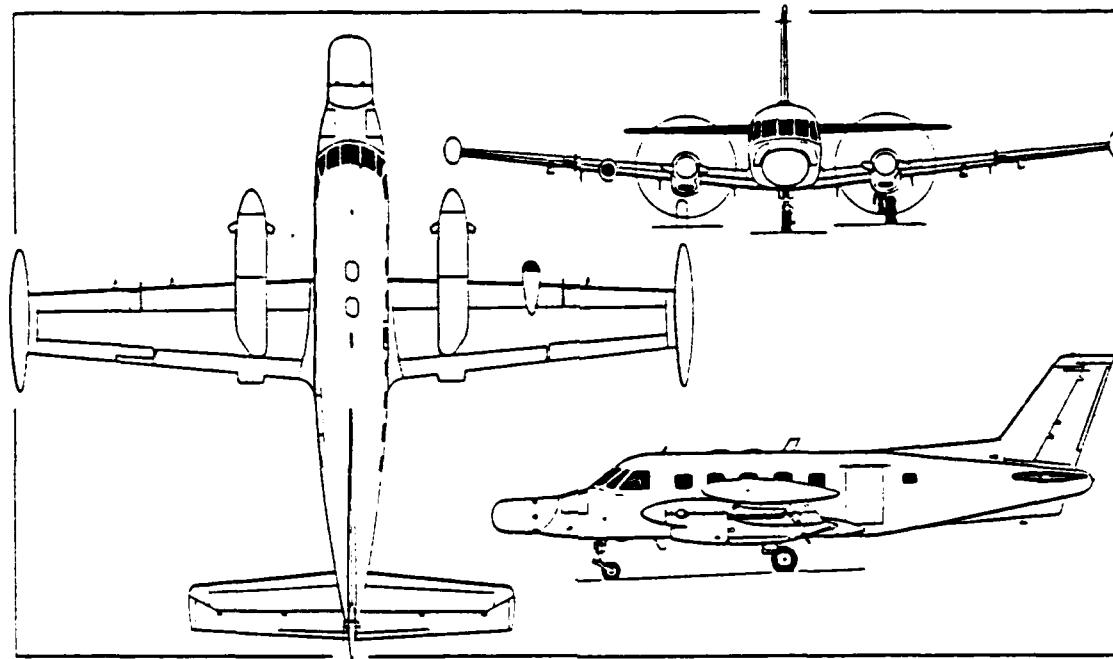
EMBRAER EMB-110P2A Bandeirante, with dihedral tailplane and other changes (Pilot Press)

Specifications

Wing Span	Height	Length
-----	-----	-----
15.33 m (50'3.5")	4.92 m (16'1.75")	15.10 m (49'6.5")
Maximum T.O. Weight	Maximum Speed	Maximum Range
-----	-----	-----
5,900 kg (13,000 lbs)	248 knots (286 mph)	1,068 nm (1,220 mi)

Figure 1. EMB 110 Aircraft (52:10)

## BANDEIRANTE



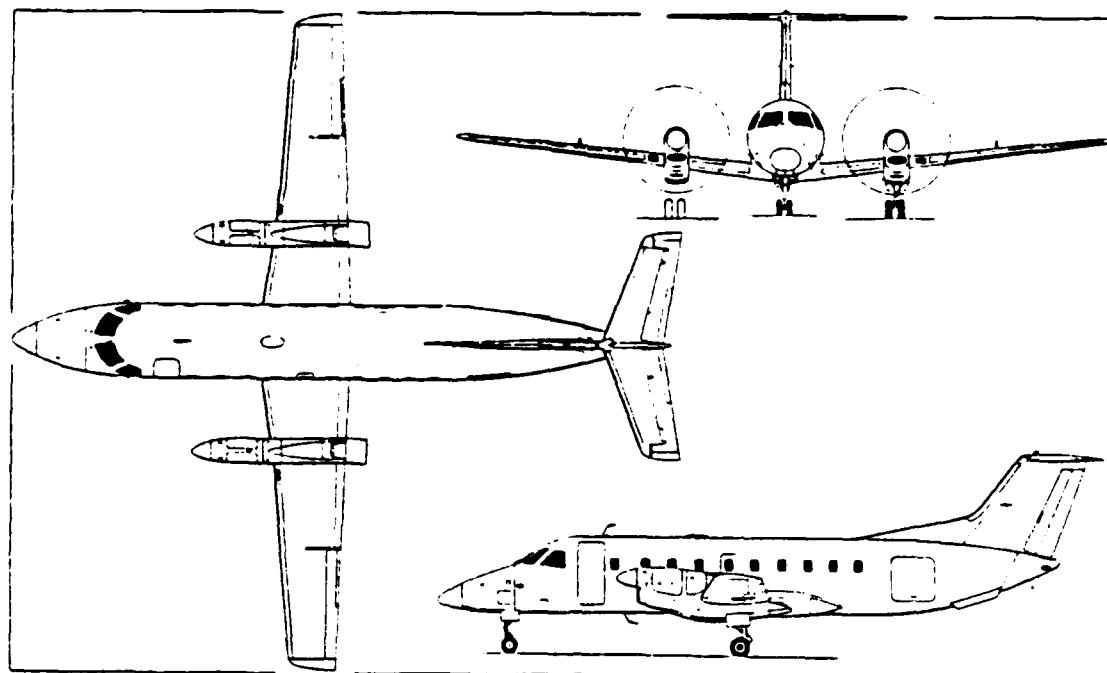
EMB-111 patrol version of the Bandeirante, developed by EMBRAER (Pilot Press)

### Specifications

Wing Span	Height	Length
-----	-----	-----
15.95 m (50' 4")	4.91 m (16' 1.25")	14.91 m (48' 11")
Maximum T.O. Weight	Maximum Speed	Maximum Range
-----	-----	-----
7,000 kg (15,432 lbs)	194 knots (223 mph)	1,590 nm (1,830 mi)

Figure 2. EMB 111 Aircraft (52:12)

BRASILIA



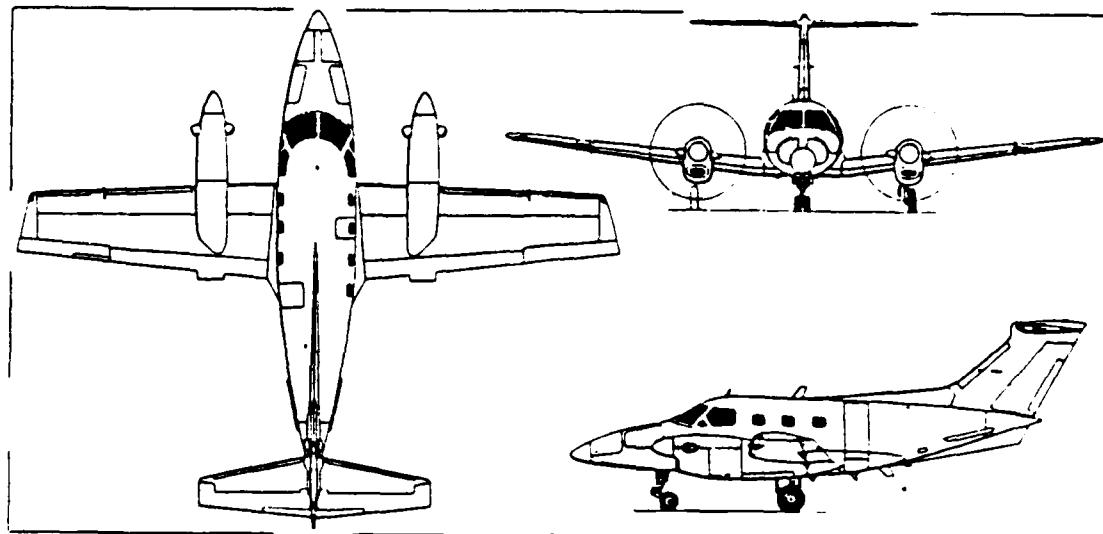
EMBRAER EMB-120 Brasilia twin-turboprop transport (*Pilot Press*)

Specifications

Wing Span	Height	Length
-----	-----	-----
19.78 m (64'10.75")	6.35 m (20'10")	20.00 m (65'7.5")
Maximum T.O. Weight	Maximum Speed	Maximum Range
-----	-----	-----
10,800 kg (23,810 lbs)	312 knots (359 mph)	1,700 nm (1,957 mi)

Figure 3. EMB 120 Aircraft (52:13)

## XINGU II



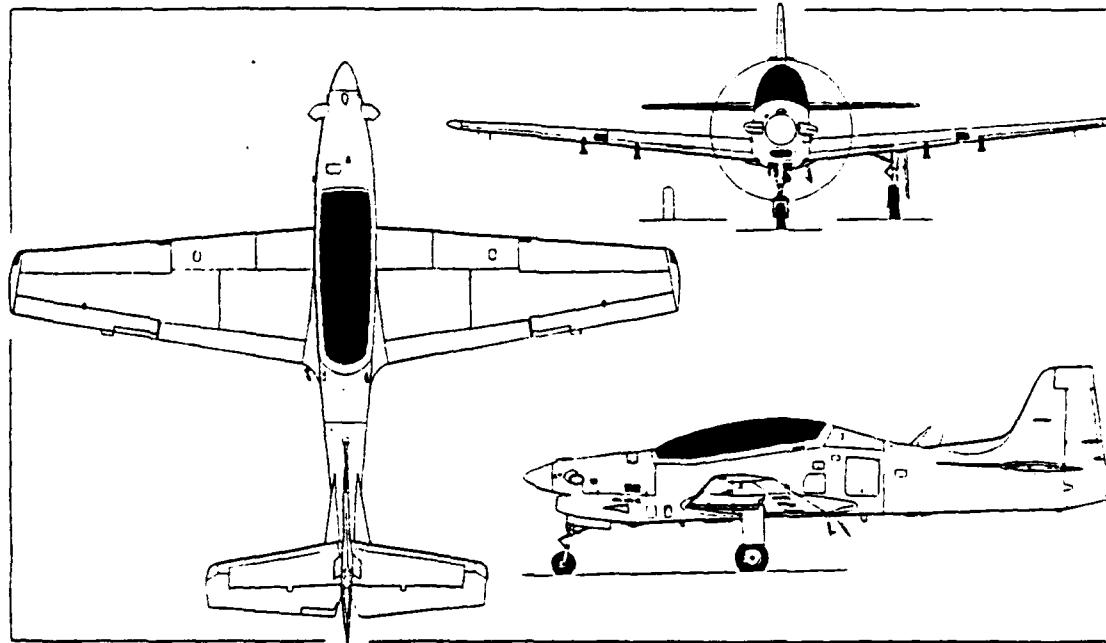
EMBRAER EMB-121A1 Xingu II nine-passenger twin-turboprop transport (Pilot Press)

### Specifications

Wing Span	Height	Length
-----	-----	-----
14.45 m (47' 5")	4.74 m (15' 6.5")	12.25 m (40' 2.25")
Maximum T.O. Weight	Maximum Speed	Maximum Range
-----	-----	-----
5,670 kg (12,500 lbs)	252 knots (290 mph)	1,268 nm (1,460 mi)

Figure 4. EMB 121 Aircraft (52:14)

## TUCANO



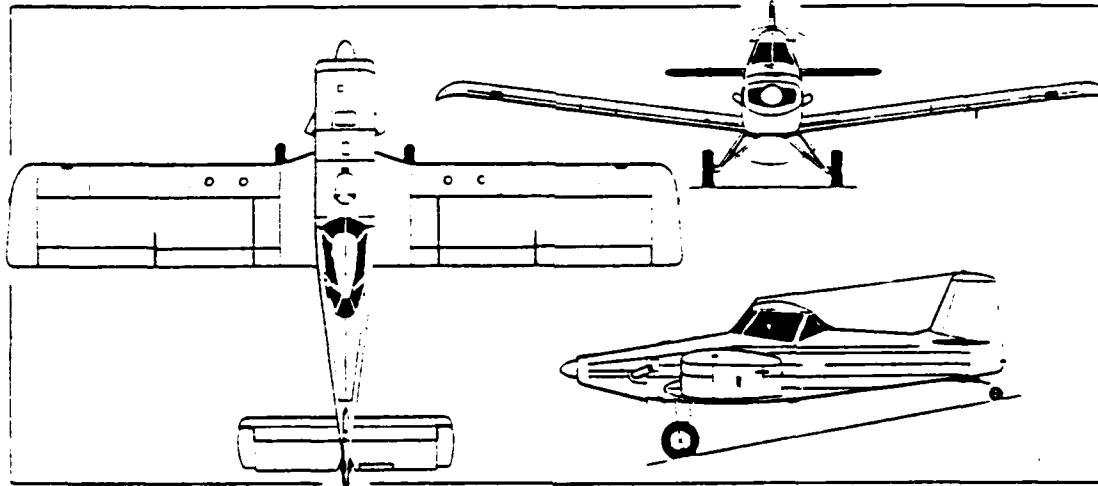
**EMBRAER EMB-312 Tucano basic trainer (Pratt & Whitney Canada PT6A-25C turboprop engine)**  
*(Pilot Press)*

### Specifications

Wing Span	Height	Length
-----	-----	-----
11.14 m {36' 6.5"}	3.40 m {11' .5"}	9.86 m {32' 4.25"}
Maximum T.O. Weight	Maximum Speed	Maximum Range
-----	-----	-----
3,175 kg {7,000 lbs}	280 knots {322 mph}	1,797 nm {2,069 mi} (with tanks)

Figure 5. EMB 312 Aircraft (52:15)

## IPANEMA



EMBRAER EMB-201A Ipanema single-seat agricultural aircraft (Pilot Press)

### Specifications

Wing Span	Height	Length
-----	-----	-----
11.20 m (36' 9")	2.2 m (7' 2.5")	7.43 m (24' 4.5")
Maximum T.O. Weight	Maximum Speed	Maximum Range
-----	-----	-----
1,550 kg (3,417 lbs)	147 knots (169 mph)	506 nm (583 mi)

Figure 6. EMB 201 Aircraft (52:16)

Appendix B: AMX Aircraft

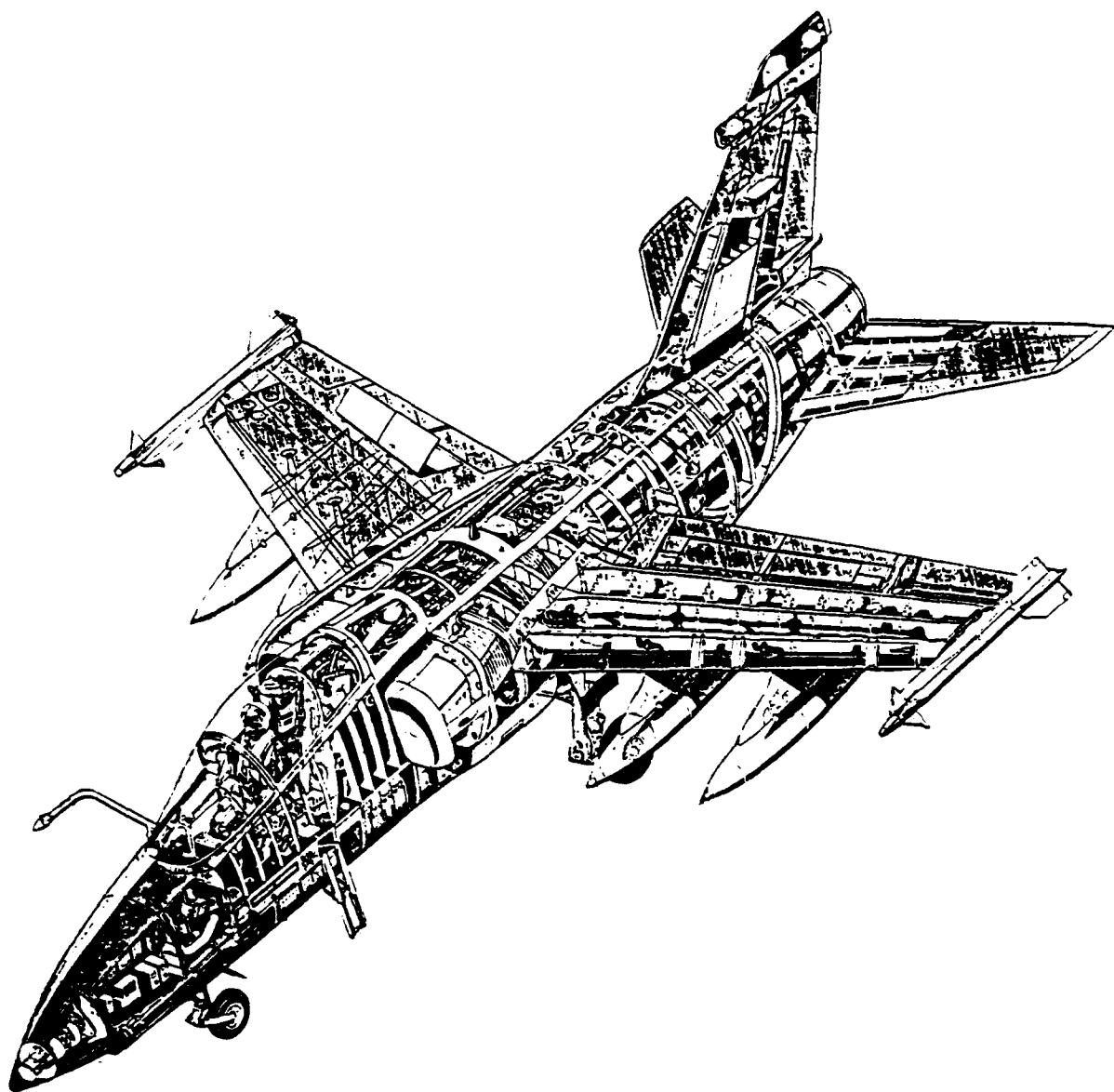


Figure 7. AMX Overview

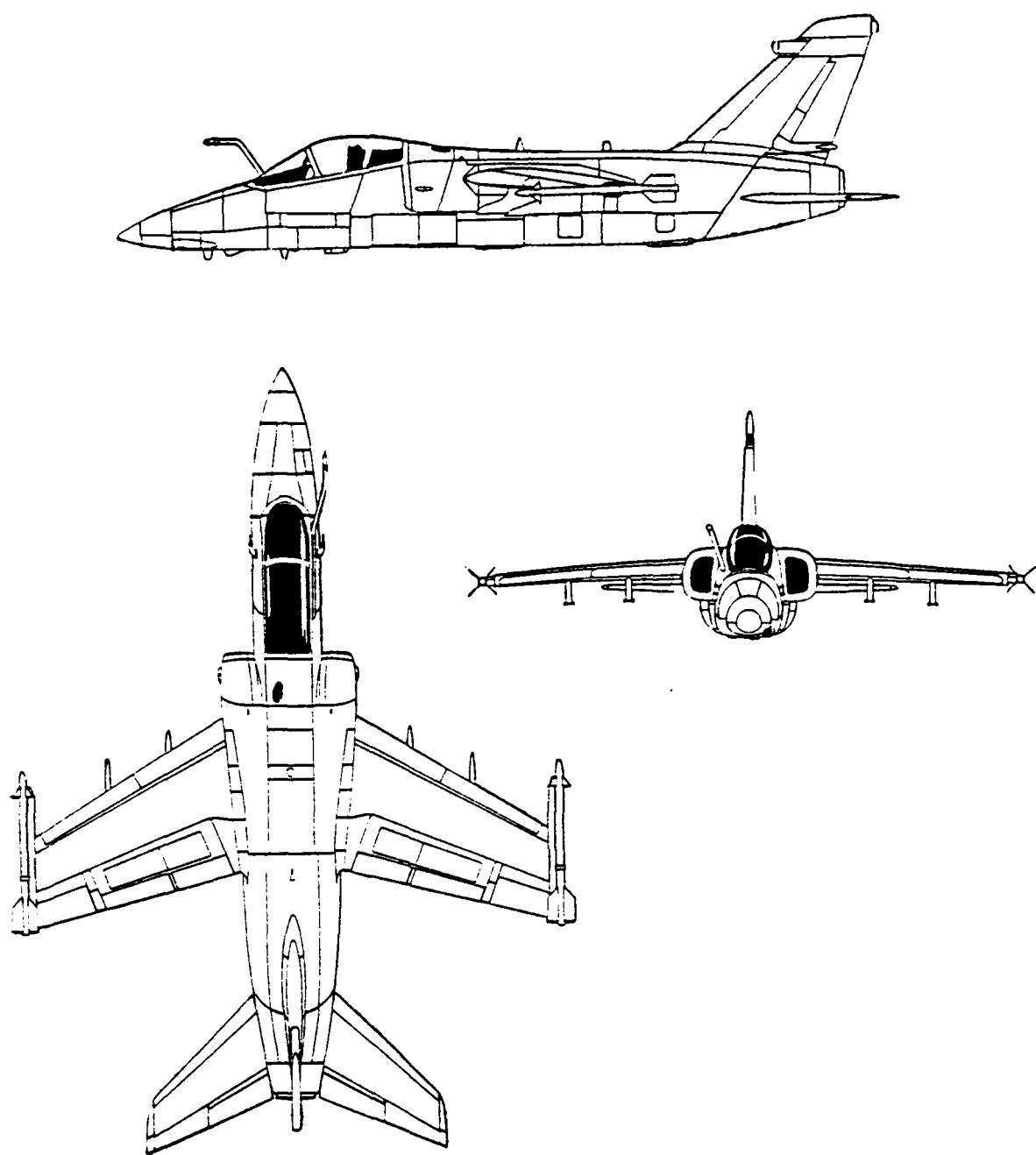


Figure 8. AMX Outline

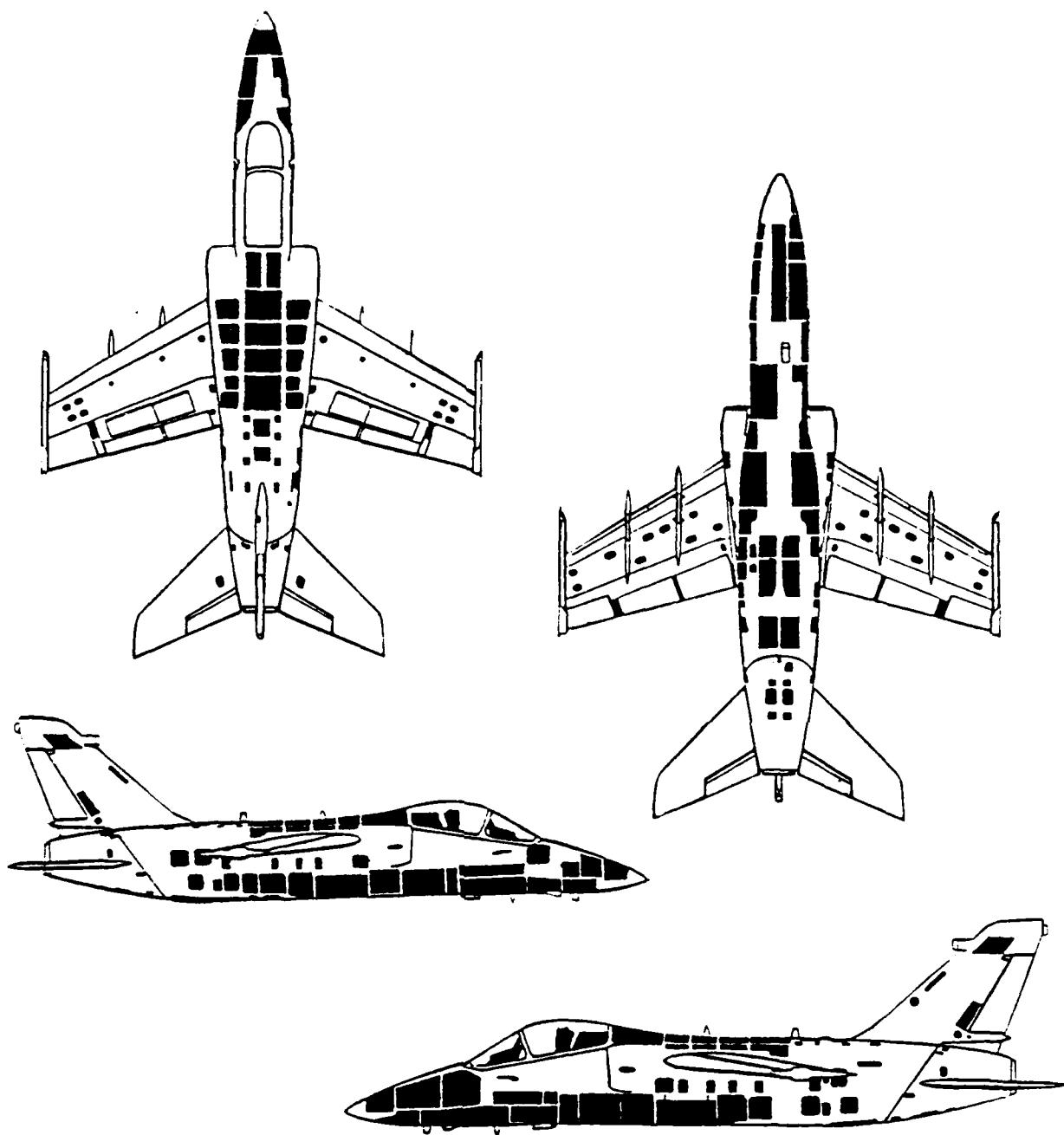


Figure 9. AMX Maintenance Access

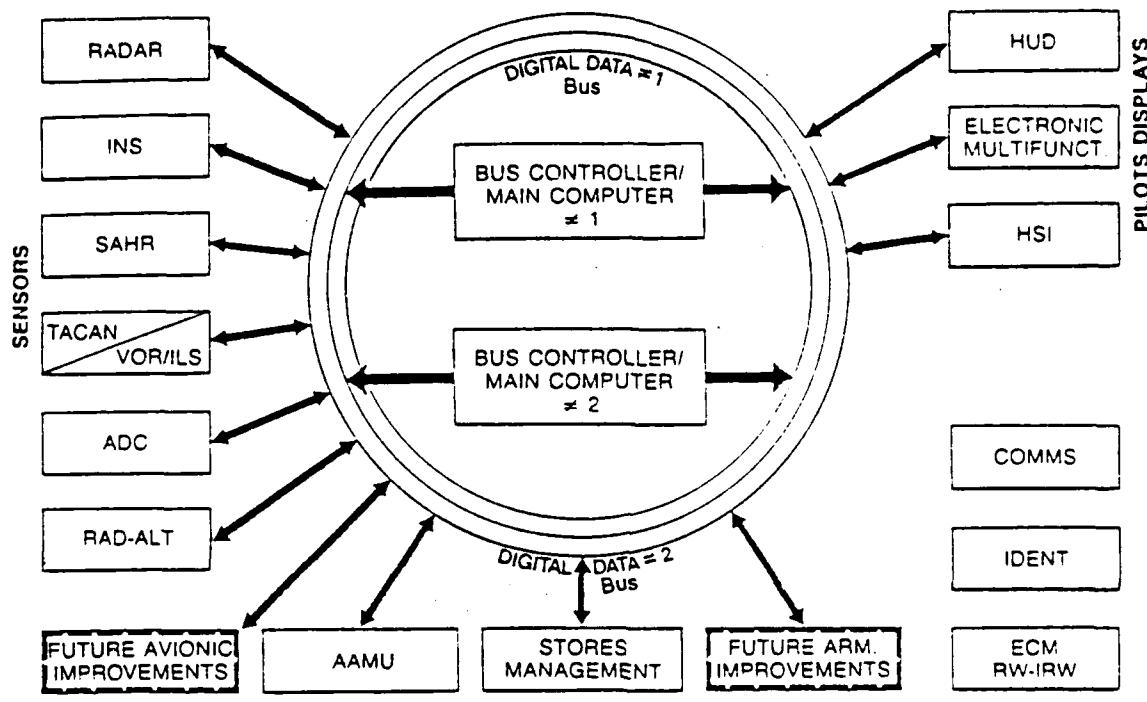


Figure 10. AMX Avionics

## Appendix C: Map

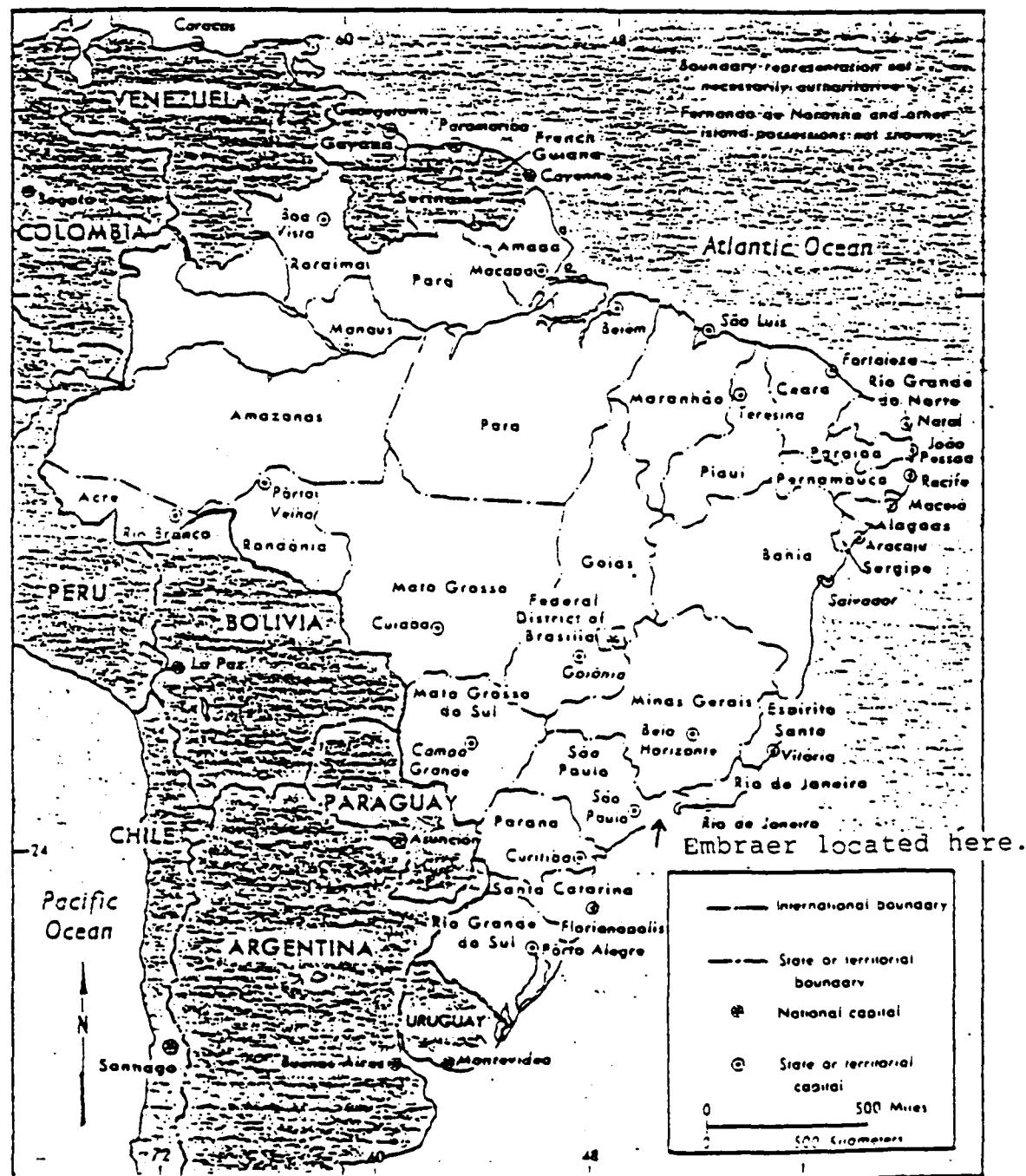


Figure 11. Brazil States and Territories

Appendix D: MOU Brazil-US Industrial-Military Cooperation

FINAL REPORT OF THE UNITED STATES-BRAZIL  
INDUSTRIAL/MILITARY WORKING GROUP

Persuant to the understandings reached by Presidents Ronald Reagan and Joao Figueiredo during the former's visit to Brazil in December 1982, a Working Group was established to study bilateral industrial-military cooperation. The Working Group's principal purposes were to review existing industrial-military cooperation, to consider the potential for additional cooperation that would be compatible with the legal and policy requirements of both nations, and to establish the inter-governmental understandings required for enhanced cooperation in this area.

The Working Group was co-chaired by Mr. Richard L. Armitage, U.S Assistant Secretary of Defense for International Security Affairs, and General Rubens Mario Brum Negreiros, Vice-Chief of the Brazilian Armed Forces General Staff. Delegation lists are attached at Annex I.

The Working Group readily acknowledged that the United States and Brazil have different governmental structures, legal systems, economic situations, and geo-political considerations. It recognized, moreover, that such differences

are natural for two independent and sovereign nations. More important, the Working Group clearly perceived that the common values and interests of the two nations far outweigh their differences. The Working Group focused its principal efforts on highlighting activities that could further strengthen bilateral cooperative programs.

The delegations held their first informal meetings in Washington, D.C. June 13-14, 1983, to consider whether a formal Working Group should be created to consider expanded industrial-military cooperation. The meetings, designed essentially to exchange data and information, explored the respective judicial and constitutional systems of both countries, their experiences with third countries, and issues affecting technology transfer in the industrial-military area. As a result of the information and appreciation developed during these exchanges, the delegations agreed to convoke a formal Working Group meeting in Brazil during August.

The Working Group convened officially in late August after extensive preparations. The Group began its activities on August 29 by visiting several industrial and research facilities near Sao Jose dos Campos. It then held its formal sessions in Brasilia August 30-31. Following this highly successful meeting, members of the Group visited two industrial

and research facilities near Campinas on September 1.

Throughout the discussions in June and August, the delegations clearly expressed, the principal concerns of their respective authorities. The Brazilian delegation stressed that its government, as part of its economic development policy, is determined to consolidate and strengthen Brazil's military-related industry. To achieve this objective, the Government of Brazil wishes to promote an effective transfer of technology. This process should enable its nationals to gain an increasing familiarity with and control of modern technology. The United States delegation expressed the desire of its authorities to encourage an increased bilateral exchange of information. It emphasized its desire that both countries derive maximum benefit from such exchanges within the framework of the respective laws and policies of both Governments.

The meetings were notable for their constructive and mature deliberations. The discussions reflected the strong ties of friendship that unite the two countries and which permit a thorough and candid analysis of the objectives and concerns of both nations. The delegations utilized this highly productive environment to pursue objectives that would be of genuine mutual interest and would advance the broader bilateral relationship. This positive, considerate approach undoubtedly

explains the Working Group's success in achieving an understanding.

During the course of its deliberations, the Working Group:

1. Concluded that increased industrial-military cooperation is achievable and would benefit both nations;
2. Initialed a Memorandum of Understanding which establishes the intent of both governments to encourage industrial-military cooperation and sets the parameters for safeguarding the classified military information exchanged pursuant to the Memorandum. The Memorandum of Understanding, attached hereto as annex 2, will be brought into force by an exchange of diplomatic notes;
3. Agreed that both governments will promote more visits by technical personnel in order to foster technology exchanges;
4. Agreed that their respective governments will set the policy guidelines and take the administrative steps necessary to implement the foregoing understandings;
5. Conducted preliminary consultations on a General

Security of Military Information Agreement;

6. Undertook to promote, within the appropriate fora, a continuation of its discussions in order to amplify the understandings already reached; and
7. Having determined that it had achieved its presidential mandate, closed its formal activities.

(Signed)

Mr. Richard L. Armitage  
(U. S. Delegation)

Gen. Rubens M. Brum Negreiro  
(Brazil Delegation)

57635  
9/20/83

MEMORANDUM OF UNDERSTANDING ON INDUSTRIAL-MILITARY COOPERATION

PREAMBLE: THE GOVERNMENT OF THE UNITED STATES OF AMERICA AND THE GOVERNMENT OF THE FEDERATIVE REPUBLIC OF BRAZIL, HEREIN AFTER REFERRED TO AS THE GOVERNMENTS:

IN FULFILLMENT OF AN UNDERSTANDING REACHED BY THE PRESIDENT OF THE UNITED STATES AND THE PRESIDENT OF BRAZIL, AND:

TO MAKE BETTER USE OF THEIR RESPECTIVE INDUSTRIAL AND MILITARY CAPABILITIES THROUGH COOPERATION IN THE DEVELOPMENT AND PRODUCTION OF MILITARY RELATED PRODUCTS IN ORDER TO BENEFIT BOTH COUNTRIES:

HEREBY ENTER INTO THIS MEMORANDUM OF UNDERSTANDING (MOU) WHICH SETS FORTH THE GUIDING PRINCIPLES GOVERNING INDUSTRIAL-MILITARY COOPERATION.

ARTICLE 1. PRINCIPLES GOVERNING INDUSTRIAL-MILITARY COOPERATION.

1.1. BOTH GOVERNMENTS INTEND TO ESTABLISH INDUSTRIAL-MILITARY COOPERATION THROUGH PROGRAMS SUBJECT TO THE APPROVAL OF THE TWO GOVERNMENTS. SUCH COOPERATIVE PROGRAMS WILL BE CONSISTENT WITH THE ESTABLISHED LAWS, REGULATIONS AND POLICIES OF THE TWO GOVERNMENTS, AND:

1.1.1. SHOULD TAKE INTO CONSIDERATION THE MILITARY REQUIREMENTS AND OBJECTIVES OF EACH GOVERNMENT.

1.1.2. SHOULD REPRESENT A COST-EFFECTIVE AND RATIONAL INVESTMENT.

1.1.3. SHOULD EMBODY RECIPROCAL BENEFITS TO BOTH GOVERNMENTS, WHILE BEING STRUCTURED TO ADJUST TO THE AVAILABLE RESOURCES AND CURRENT BUSINESS PRACTICES.

1.1.4. SHOULD CONTRIBUTE TO THE ENHANCEMENT OF THE CAPABILITIES OF THE ARMED FORCES OF EACH COUNTRY.

1.2. THE GOVERNMENTS AGREE TO EXCHANGE TECHNOLOGY TO FACILITATE APPROVED COOPERATIVE PROGRAMS, IN ACCORDANCE WITH THE FOLLOWING:

1.2.1. THE PROVISIONS OF A GENERAL SECURITY OF MILITARY INFORMATION AGREEMENT AND SUCH OTHER ARRANGEMENTS TO BE NEGOTIATED BY THE RESPECTIVE GOVERNMENTS FOR THE PROTECTION FROM UNAUTHORIZED DISCLOSURE OF CLASSIFIED MILITARY INFORMATION.

1.2.2. THE LEGAL AND POLICY REQUIREMENTS FOR TECHNOLOGY TRANSFER DETERMINED BY THE RESPECTIVE GOVERNMENTS ON A CASE-BY-CASE BASIS.

1.3. BOTH GOVERNMENTS WILL PROVIDE APPROPRIATE POLICY GUIDANCE AND WILL ESTABLISH ADMINISTRATIVE PROCEDURES WITHIN THEIR RESPECTIVE ORGANIZATIONS IN ORDER TO FACILITATE INDUSTRIAL MILITARY COOPERATION.

1.4. TECHNICAL INFORMATION, INCLUDING TECHNICAL DATA PACKAGES (TDPs), FURNISHED BY ONE GOVERNMENT TO THE OTHER GOVERNMENT OR TO PERSONS IN THE OTHER COUNTRY FOR THE PURPOSE OF APPROVED COOPERATIVE PROGRAMS SHALL NOT BE USED FOR ANY OTHER PURPOSE WITHOUT THE PRIOR AGREEMENT OF THE ORIGINATING GOVERNMENT.

1.4.1 EACH GOVERNMENT WILL ENSURE, ACCORDING TO ITS OWN LEGISLATION, THAT TOTAL PROTECTION IS GIVEN BY ITS EMPLOYEES, AGENTS AND CONTRACTORS TO PROPRIETARY RIGHTS OR TO ANY PROTECTED OR CLASSIFIED INFORMATION THEY MAY CONTAIN.

1.4.2 TECHNICAL INFORMATION OR TECHNICAL DATA PACKAGES SHALL BE TRANSFERRED BY THE RECIPIENT GOVERNMENT TO ANY THIRD COUNTRY GOVERNMENT, TO AN ENTITY OF A THIRD COUNTRY, OR TO A PERSON OF A THIRD COUNTRY, ONLY BY MEANS OF A WRITTEN ARRANGEMENT BETWEEN BOTH GOVERNMENTS. SUCH TRANSFERS WILL BE THE SUBJECT OF CONSIDERATION ON A CASE BY CASE BASIS BEFORE A SPECIFIC PROGRAM IS IMPLEMENTED IN ACCORDANCE WITH THE TERMS OF THIS MEMORANDUM OF UNDERSTANDING.

1.4.3. EACH GOVERNMENT WILL ALSO UNDERTAKE ITS BEST EFFORTS TO ENSURE COMPLIANCE WITH THE FOREGOING PROVISIONS ON THE PART OF OTHER PERSONS IN ITS COUNTRY.

1.5. EACH GOVERNMENT WILL MAKE AVAILABLE TO THE OTHER ADEQUATE INFORMATION TO PERMIT AN ASSESSMENT OF THE FEASIBILITY OF INITIATING SPECIFIC COOPERATION PROGRAMS PROPOSED AND AGREED UPON UNDER THE PROVISIONS OF THIS MOU.

## ARTICLE 2. INTERIM SECURITY MEASURES

2.1. AS PROVIDED IN 1.2.1., THE SECURITY OF CLASSIFIED INDUSTRIAL-MILITARY INFORMATION EXCHANGED UNDER THIS MOU WILL BE SUBJECT TO ANY SECURITY AGREEMENT AND ARRANGEMENTS WHICH MAY SUBSEQUENTLY BE CONCLUDED BY THE GOVERNMENTS. UNTIL SUCH AGREEMENT AND ARRANGEMENTS ENTER INTO EFFECT, THE FOLLOWING PROVISIONS WILL APPLY:

2.1.1. ANY ITEMS, PLANS, SPECIFICATIONS, TECHNICAL DATA OR OTHER INFORMATION FURNISHED IN CONNECTION WITH THE IMPLEMENTATION OF THIS MOU WHICH ARE CLASSIFIED BY THE FURNISHING GOVERNMENT FOR SECURITY PURPOSES WILL BE TRANSFERRED THROUGH GOVERNMENT CHANNELS, AND THE RECEIVING GOVERNMENT SHALL MAINTAIN A SIMILAR CLASSIFICATION AND EMPLOY SECURITY MEASURES SUBSTANTIALLY EQUIVALENT TO THOSE EMPLOYED BY THE FURNISHING GOVERNMENT.

2.1.2. ALL CLASSIFIED INFORMATION COMMUNICATED BETWEEN THE GOVERNMENTS OR THROUGH THEM TO INDUSTRY SHALL BE PROTECTED IN ACCORDANCE WITH THE FOLLOWING PRINCIPLES:

2.1.2.A. CLASSIFIED INDUSTRIAL-MILITARY INFORMATION WILL BE PROTECTED IN EACH COUNTRY ACCORDING TO ITS OWN LAWS AND REGULATIONS FOR SAFEGUARDING SUCH INFORMATION.

2.1.2.B. AUTHORIZATIONS FOR ACCESS TO CLASSIFIED INDUSTRIAL-MILITARY INFORMATION ARE THE RESPONSIBILITY OF THE GOVERNMENT AUTHORITIES OF THE COUNTRY IN WHICH SUCH INFORMATION IS SAFEGUARDED.

2.1.2.C. CLASSIFIED INDUSTRIAL-MILITARY INFORMATION WILL BE REVEALED ONLY TO THOSE PERSONS, CIVILIAN OR MILITARY, OFFICIALS OR PRIVATE PERSONS, WHO HAVE AN APPROPRIATE SECURITY CLEARANCE AND THE NEED TO KNOW BECAUSE OF THEIR FUNCTIONS OR POSITION.

2.1.3. INFORMATION PROVIDED BY EITHER GOVERNMENT TO THE OTHER ON CONDITION THAT IT REMAIN CLASSIFIED SHALL EITHER RETAIN ITS ORIGINAL CLASSIFICATION OR BE ASSIGNED A CLASSIFICATION EQUIVALENT TO THAT REQUIRED BY THE OTHER GOVERNMENT, IN ORDER TO ENSURE PROTECTION AGAINST UNAUTHORIZED DISCLOSURE. TO ASSIST IN PROVIDING THE DESIRED PROTECTION, EACH GOVERNMENT WILL MARK SUCH INFORMATION WITH A LEGEND INDICATING THE ORIGIN OF THE INFORMATION, THAT IT RELATES TO THIS MOU, AND THAT THE INFORMATION IS FURNISHED IN CONFIDENCE.

2.1.3.1. CLASSIFIED INDUSTRIAL-MILITARY INFORMATION WHICH LEGALLY BECOMES PART OF THE PUBLIC DOMAIN OR WHICH HAS ITS SECURITY CLASSIFICATION MODIFIED BY THE COUNTRY WHICH RELEASED IT WILL, ACCORDINGLY, BE EXEMPT FROM THE PROVISIONS OF THIS MOU OR WILL BE RECLASSIFIED IN A WAY WHICH IS EQUIVALENT TO ITS RECLASSIFICATION IN THE ORIGINATING COUNTRY. UNDER NO CIRCUMSTANCES MAY THERE BE A DIFFERENT CLASSIFICATION OF SUCH INFORMATION BETWEEN THE TWO GOVERNMENTS.

2.1.4. EACH GOVERNMENT UPON REQUEST, WILL PERMIT VISITS TO ITS TERRITORY BY SECURITY EXPERTS OF THE OTHER GOVERNMENT, TO DISCUSS SECURITY RULES AND PROCEDURES RELATED TO CLASSIFIED INDUSTRIAL-MILITARY INFORMATION RECEIVED FROM THE OTHER GOVERNMENT WITHIN THE CONTEXT OF THE COOPERATIVE PROGRAMS. THE GOVERNMENT OF THE VISITED COUNTRY WILL ASSIST SUCH EXPERTS IN VERIFYING IN A MUTUALLY CONVENIENT WAY, THAT INFORMATION PROVIDED TO IT BY THE OTHER GOVERNMENT IS BEING ADEQUATELY PROTECTED.

2.1.5. BOTH GOVERNMENTS WILL INVESTIGATE, IN THEIR RESPECTIVE TERRORIES, ALL CASES IN WHICH IT IS KNOWN, OR THERE ARE GROUNDS FOR SUSPECTING, THAT CLASSIFIED INDUSTRIAL-MILITARY INFORMATION EXCHANGED UNDER PROVISIONS OF THIS MOU HAS BEEN LOST OR DISCLOSED TO UNAUTHORIZED PERSONS. IN THE CASE OF SUCH OCCURRENCES, EACH GOVERNMENT WILL ALSO PROMPTLY AND FULLY INFORM THE OTHER GOVERNMENT OF THE DETAILS OF ANY SUCH OCCURRENCES AS WELL AS OF THE FINAL RESULTS OF THE INVESTIGATION AND OF CORRECTIVE ACTION TAKEN TO PRECLUDE RECURRENCES.

#### ARTICLE 3. INDUSTRY PARTICIPATION

3.1. IMPLEMENTATION OF THIS MOU WILL INVOLVE SIGNIFICANT INDUSTRIAL PARTICIPATION. NOTWITHSTANDING THE GOVERNMENTAL PROCEDURES TO FACILITATE THE IMPLEMENTATION OF THIS MOU, IT WILL BE THE BASIC RESPONSIBILITY OF THE INDUSTRIES IN EACH COUNTRY TO ADVISE THE RESPECTIVE GOVERNMENTS OF THEIR CAPABILITIES FOR COOPERATION AND TO CARRY OUT THE SUPPORTING ACTIONS NECESSARY FOR INDUSTRIAL PARTICIPATION.

3.2. EACH GOVERNMENT WILL BE RESPONSIBLE FOR COMMUNICATING TO ITS RELEVANT INDUSTRIES THE BASIC TERMS OF THIS MOU AND THE APPROPRIATE IMPLEMENTING GUIDANCE. EACH GOVERNMENT SHALL TAKE STEPS TO ENSURE THAT ITS INDUSTRIES COMPLY WITH THE PROVISIONS OF THIS MOU REGARDING USE AND TRANSFER OF TECHNICAL INFORMATION AND TDPS, AND REGULATIONS PERTAINING TO SECURITY AND TO SAFEGUARDING CLASSIFIED INDUSTRIAL MILITARY INFORMATION.

3.3. TO ENCOURAGE THE EXCHANGE OF INFORMATION IN ACCORDANCE WITH THIS MOU, EACH GOVERNMENT WILL FACILITATE VISITS BY AUTHORIZED OFFICIALS AND REPRESENTATIVES OF THE OTHER COUNTRY TO APPROPRIATE MILITARY AND INDUSTRIAL FACILITIES FOR THE DEVELOPMENT AND EXECUTION OF COOPERATIVE PROGRAMS.

#### ARTICLE 4. DURATION

4.1. THIS MOU WILL REMAIN IN EFFECT FOR A FIVE-YEAR PERIOD. IT MAY BE EXTENDED FOR SUCCESSIVE FIVE-YEAR PERIODS UPON AGREEMENT BY THE RESPECTIVE GOVERNMENTS.

4.2. THIS MOU MAY BE TERMINATED AT ANY TIME BY EITHER GOVERNMENT WHICH WILL NOTIFY THE OTHER GOVERNMENT THROUGH DIPLOMATIC CHANNELS. THE TERMINATION WILL TAKE EFFECT 180 DAYS AFTER THE DATE OF THE NOTIFICATION.

4.3. THE TERMINATION OF THIS MOU SHALL, UNDER NO CIRCUMSTANCES, AFFECT THE PROTECTION GRANTED IN IT TO THE CLASSIFIED INDUSTRIAL-MILITARY INFORMATION WHICH HAD BEEN EXCHANGED WHILE IT WAS IN EFFECT.

4.4. SHOULD THIS MOU BE TERMINATED, ANY CONTRACT ENTERED INTO UNDER THE TERMS OF THIS MOU SHALL CONTINUE IN EFFECT, UNLESS THE CONTRACT IS TERMINATED IN ACCORDANCE WITH ITS OWN TERMS, OR AS MUTUALLY AGREED BY BOTH PARTIES.

ARTICLE 5. ENTRY INTO FORCE

5.1. THIS MOU WILL ENTER INTO FORCE UPON THE EXCHANGE OF DIPLOMATIC NOTES.

5.2. THE TWO GOVERNMENTS MAY ENTER INTO SUPPLEMENTARY PROTOCOLS TO THIS MOU, IF JUDGED NECESSARY IN LIGHT OF EXPERIENCE.

5.3. ANY AMENDMENTS TO THIS MOU WILL ENTER INTO EFFECT THROUGH AN EXCHANGE OF DIPLOMATIC NOTES.

BRASILIA, AUGUST 31, 1983

*REB* *—* *JF*

Appendix E: Costs and Breakeven Charts

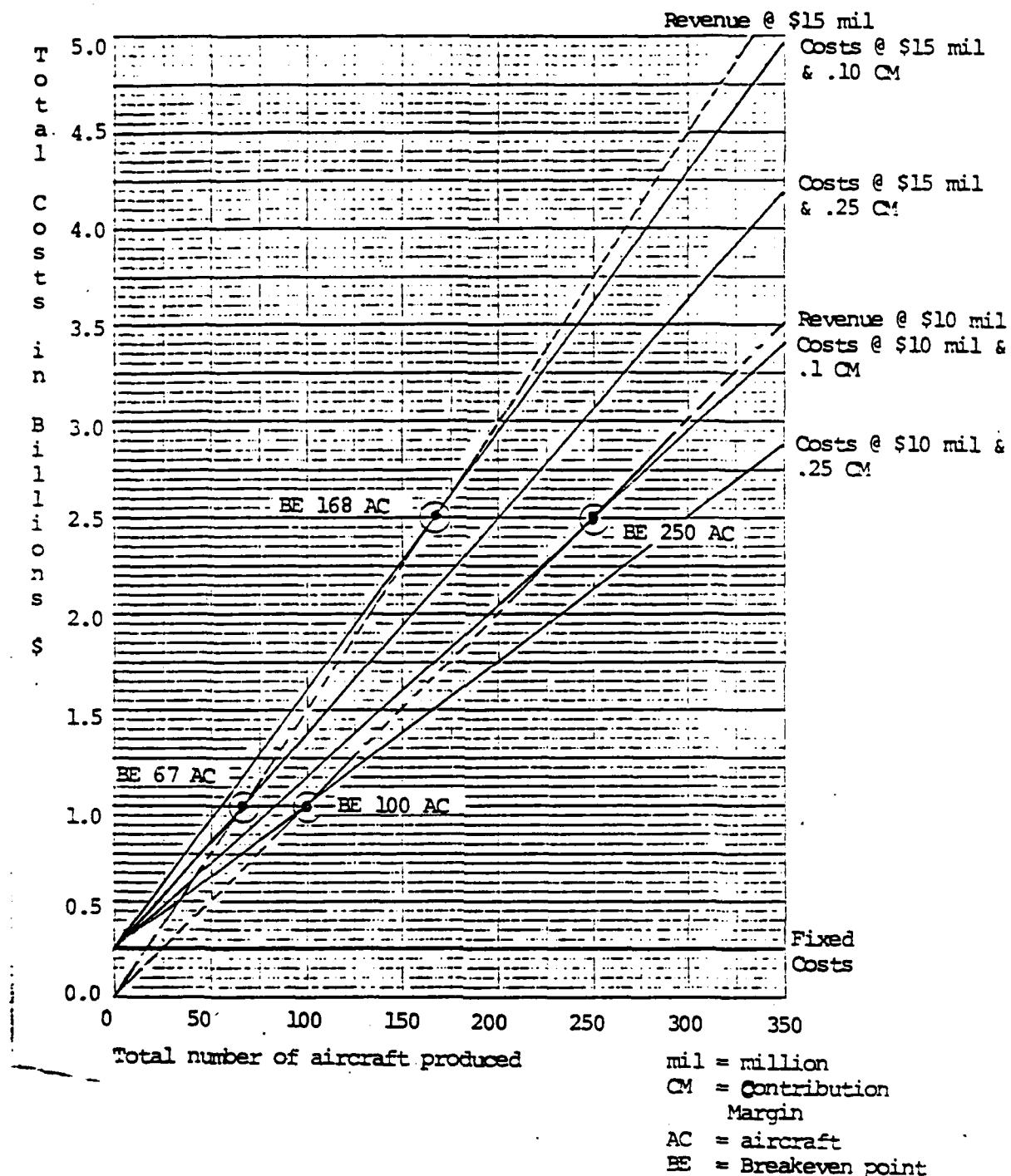


Figure 12. Licensing's Fixed and Variable Costs

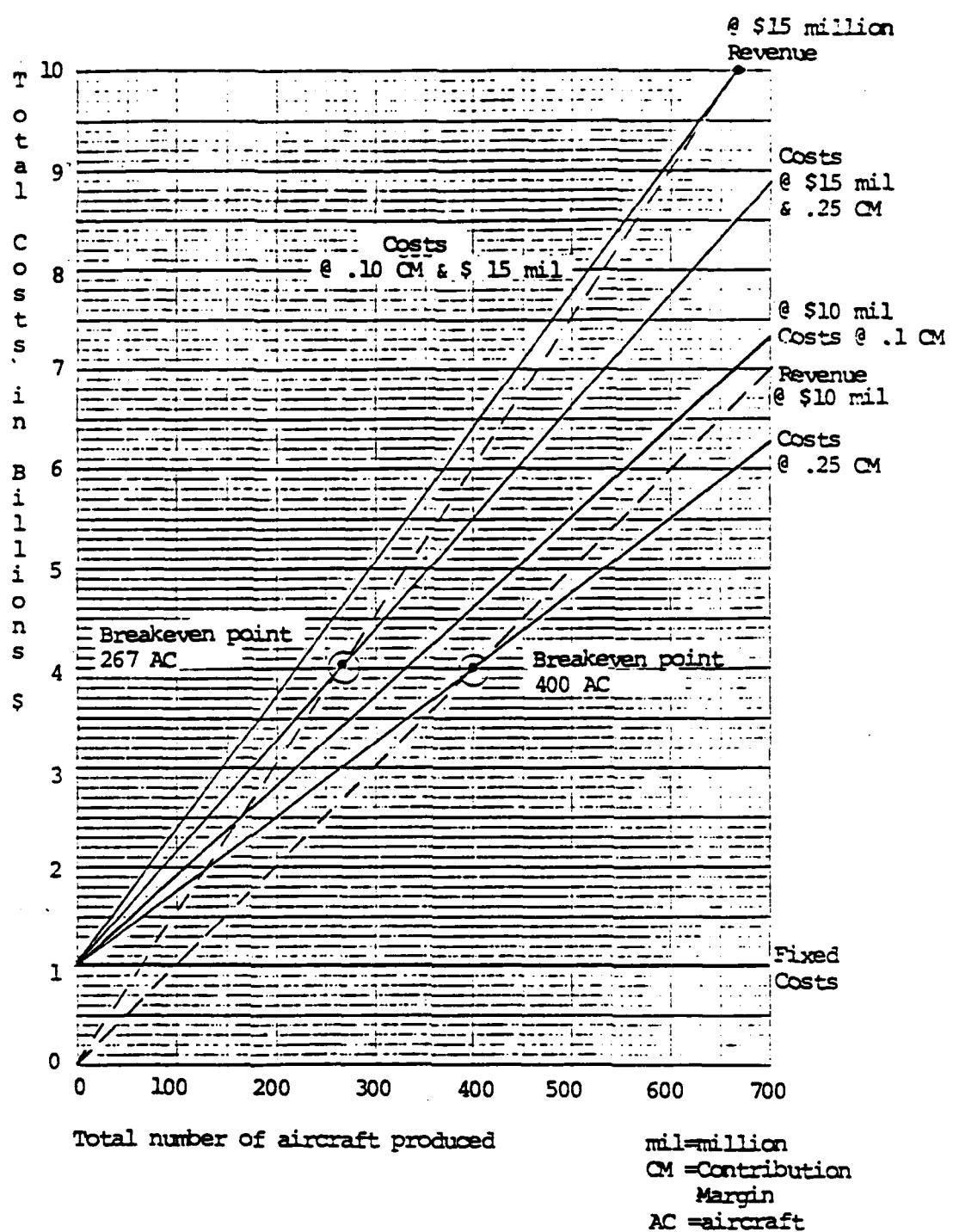


Figure 13. A Joint Venture's Fixed and Variable Costs

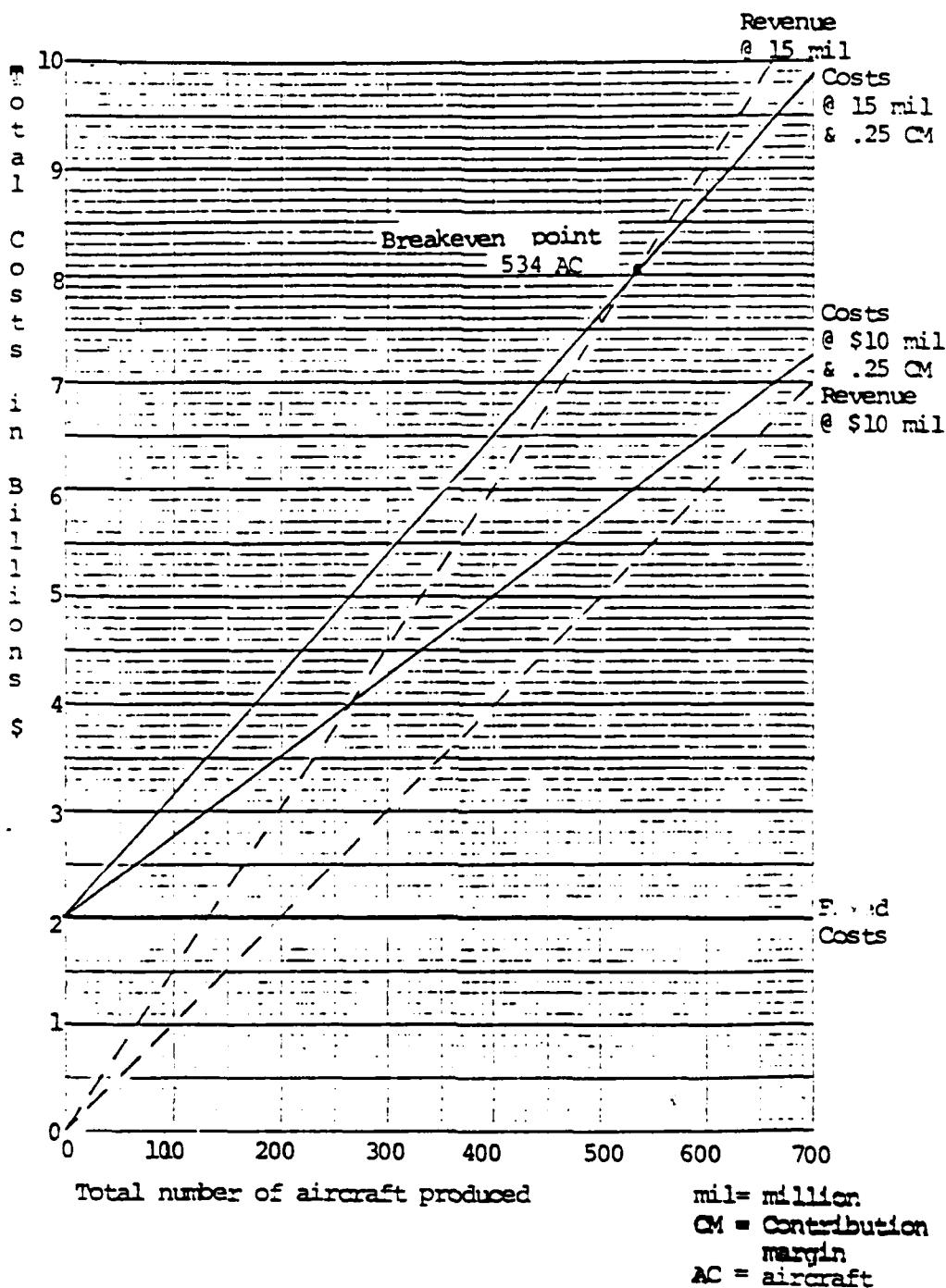


Figure 14. An Internal Development's Fixed and Variable Costs

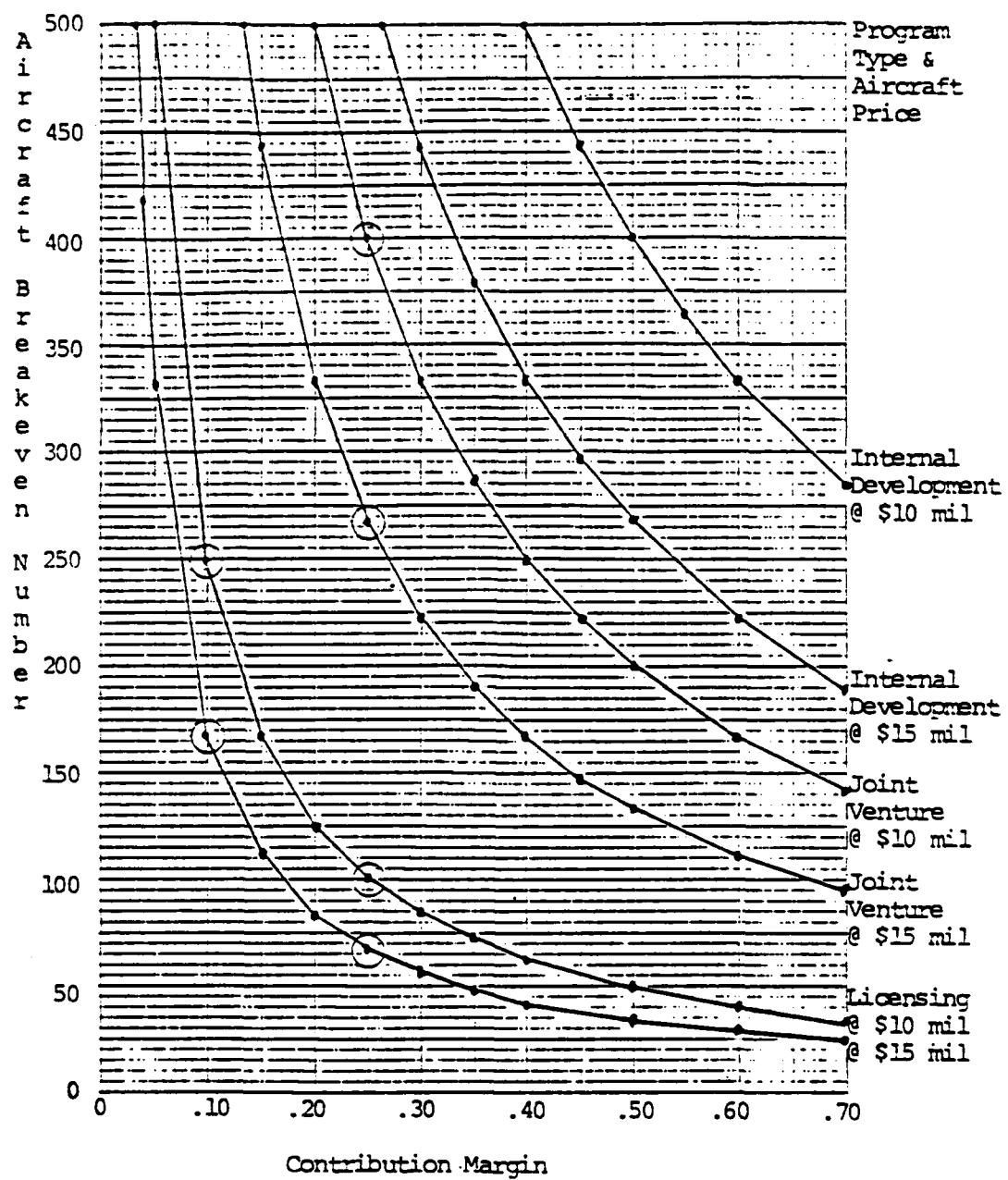


Figure 15. Breakeven Number versus Contribution Margin

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Vita

**Captain Rockford J. Reiners** was born on 24 October 1959 in San Tome', Venezuela. He graduated from Parkway Central High School in St. Louis, Missouri in 1978. He then attended the U. S. Air Force Academy and earned the degree of Bachelor of Science in Civil Engineering in June 1982. His first assignment after commissioning was as an engineer on the AMRAAM (AIM-120) missile program at Eglin AFB, Florida. While at Eglin he also received the degree of Master of Science in International Relations from Troy State University and attended Squadron Officers School in residence. Captain Reiners then entered the Air Force Institute of Technology for a Master of Science in Logistics Management degree. This program lasted from May 1985 to September 1986. Captain Reiners is currently assigned to Headquarters Air Force Logistics Command, Deputy Chief of Staff Plans and Programs, (HQ AFLC/XR) Wright Patterson AFB, Ohio 45433.

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## UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE

AD-0174-8

## REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED		1b. RESTRICTIVE MARKINGS	
2a. SECURITY CLASSIFICATION AUTHORITY		3. DISTRIBUTION/AVAILABILITY OF REPORT Approved for public release; distribution unlimited.	
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE			
4. PERFORMING ORGANIZATION REPORT NUMBER(S) AFIT/GLM/LSM/86S-64		5. MONITORING ORGANIZATION REPORT NUMBER(S)	
6a. NAME OF PERFORMING ORGANIZATION School of Systems and Logistics	6b. OFFICE SYMBOL (If applicable) AFIT/LSM	7a. NAME OF MONITORING ORGANIZATION	
6c. ADDRESS (City, State and ZIP Code) Air Force Institute of Technology Wright-Patterson AFB, Ohio 45433-6583		7b. ADDRESS (City, State and ZIP Code)	
8a. NAME OF FUNDING/SPONSORING ORGANIZATION	8b. OFFICE SYMBOL (If applicable)	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER	
8c. ADDRESS (City, State and ZIP Code)		10. SOURCE OF FUNDING NOS.	
		PROGRAM ELEMENT NO.	PROJECT NO.
		TASK NO.	WORK UNIT NO.
11. TITLE (Include Security Classification) See box 19			
12. PERSONAL AUTHORIS. Rockford J. Reiners, B.S., M.S.I.R., Captain, USAF			
13a. TYPE OF REPORT MS Thesis	13b. TIME COVERED FROM _____ TO _____	14. DATE OF REPORT (Yr., Mo., Day) 1986 September	15. PAGE COUNT 178
16. SUPPLEMENTARY NOTATION			
17. COSATI CODES		18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)	
FIELD	GROUP	SUB. GR.	Aircraft Industry Administration and Management
05	03	--	
05	01	--	See box 19
19. ABSTRACT (Continue on reverse if necessary and identify by block number)			
Title: AN EXAMINATION OF BRAZIL AND THE UNITED STATES AS POTENTIAL PARTNERS IN A JOINT SUPERSONIC MILITARY FIGHTER AIRCRAFT CODEVELOPMENT AND PRODUCTION PROGRAM			
Block 17: FIELD GROUP		Block 18: SUBJECT TERMS	
01	03	Aircraft	
15	05	Logistics	
05	04	Political Science	
Approved for public release IAW AFN 100-1 John E. WOLVER 25 SEP 86 Data for Research and Professional Development Air Force Institute of Technology (AFIT) Wright-Patterson AFB OH 45433			
Thesis Chairman: Robert D. Materna, Lieutenant Colonel, USAF Instructor of Logistics Management			
20. DISTRIBUTION/AVAILABILITY OF ABSTRACT UNCLASSIFIED/UNLIMITED <input checked="" type="checkbox"/> SAME AS RPT. <input type="checkbox"/> DTIC USERS <input type="checkbox"/>		21. ABSTRACT SECURITY CLASSIFICATION UNCLASSIFIED	
22a. NAME OF RESPONSIBLE INDIVIDUAL Robert D. Materna, LTC, USAF		22b. TELEPHONE NUMBER (Include Area Code) (513) 255-5035	22c. OFFICE SYMBOL AFIT/LSM

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This thesis examines whether Brazil and the U.S. could be suitable partners in a joint supersonic military fighter aircraft program. The primary research method was a literature review accompanied by correspondence with the national aircraft corporation of Brazil, Embraer.

The research was divided into seven areas for study: aircraft design factors, aircraft production factors, aircraft operations requirements, business concerns, current activities, possible future actions, and Brazilian-U.S. relations. In addition, three approaches for a Brazilian supersonic fighter development were investigated: licensing, joint venture, and internal development.

The results of this research indicate that Brazil and the U.S. could be suitable partners for a joint supersonic fighter development program if the technology transfer and third country export requirements can be worked out to the satisfaction of both countries. Currently Brazil has an export driven aircraft industry, while the U.S. insists on approval rights for all exports of Brazilian goods containing U.S. technology.

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